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THE INSULATION RESISTANCE OF ELECTRIC LIGHTING INSTALLATIONS.

Last Thursday week Prof. Jamieson's paper on the above subject was read at the Institution of Electrical Engineers to the dullest meeting within our memory. The paper was published in our last issue and our readers will have discovered ere now that it contains little, if anything, that is new or useful, while the discussion, if it can be dignified by that name, clearly revealed the fact that insulation is one of the subjects about which a great deal can be said without arriving at any definite or satisfactory conclusion.

In his paper Prof. Jamieson seems to consider the insulation resistance of a circuit as perfectly under control, and one would gather from him that the leakage current could be predetermined with the same accuracy as the total current from the dynamo. But in practice this is not the case. A system of electric lighting conductors presents no analogy to the submarine cable referred to in the first part of his paper. In the former the wires are chopped into small pieces for the insertion of switches, fuses and lamps, while the latter consists of one unbroken wire running from continent to continent. It is only when the cable is cut up that the trouble in insulation commences and the quality of the insulating covering is in the case of electric lighting conductors but one factor out of many in determining the leakage, whereas in the submarine cable it is the only factor. In considering the question of insulation it is necessary to remember these things, because while the resistance of the wire covering can be made any function of the voltage used, the insulation resistance of the switches, fuses, lampholders, &c., cannot. The moral is that the insulation of these fittings should always be sufficiently good for the highest potential for which they will be used; if the potential falls below this, they are none the worse for being better than is absolutely necessary.

But the fittings are not the only part of the installation in which the insulation is not proportional to the voltage. It is well known that the insulation resistance of the dynamo does not depend on the potential for which it is wound. There is not an additional lap of cotton on the wires for every additional 50 volts, nor are the coats of rubber varnish which the machine receives proportional to the difference of potential. In modern dynamos the space taken up by the insulating material on the armature and magnet cores is the same for voltages varying from 50 to 110, and as a consequence the percentage of current leaking goes up as the square of the volts. Any rule which assumes that the insulation resistance increases with the E.M.F. according to any definite law is necessarily absurd, and we think the insulation of their machines may be safely left to the makers. The practical experience of the latter is worth any number of rules, and it may be fairly assumed that if the dynamos undergo the Admiralty test with satisfactory results the insulation resistance is sufficiently good. If the leakage current is not visible when the test is applied, it is certainly not worth consideration. We do not require to know the exact resistance in ohms, all that we wish to ascertain is that in working it shall not fall below a certain value, and that value is reached when a spark becomes visible on stroking the frame of the dynamo with the free end of a wire attached to either of the terminals.

The rule given by Prof. Jamieson for the insulation resistance of the conductors is of course an empirical one, and if it were possible to put up installations in accordance with it, the percentage of current leaking to earth would for a given number of lamps increase simply as the E.M.F. employed. Quite different to this is the rule formulated by the Society of Telegraph-Engineers, which defines the required insulation resistance as that which will prevent the greatest leakage from exceeding $\frac{1}{5000}$ part of the total current intended for the lamps. As one of the speakers pointed out, there is really no comparison between the two tables in the paper. In Jamieson's for a given number of lamps the insulation is *directly* proportional to the E.M.F., while in the Society's rule it is as the *square* of the E.M.F. To take a case, the insulation resistance for an installation of 500 100-volt lamps should be according to the former $20{,}000^{\omega}$, while according to the latter it need not be more than $1{,}666^{\omega}$. If there are 500 lamps of 50 volts the tables give $10{,}000^{\omega}$ and 417^{ω} respectively. This is a difference with a vengeance, and it would be well, as Prof. Jamieson says, if we could come to some general agreement on the subject.

It may be conceded that, so far as rendering electric lighting safe is concerned, the insurance companies have equal interests with contractors and others who are doing their best to extend illumination by electricity. In the last edition of the Phœnix Fire Office Rules the inferior limit for the insulation resistance of the distribution part of installations has been fixed at what we believe contractors regard as a reasonable figure. The resistance required is pretty high, but we understand it is an amount easily attained by careful workmanship. It is a purely empirical rule applicable to circuits of 200 volts, and demanding an insulation resistance of 12·5 megohms for one lamp, this divided by the number of lamps giving the figure below which the insulation of the circuit for continuous current working must not fall. It is mentioned that for alternating currents the insulation should be twice the above value. As it stands the rule is liable to misinterpretation, for, nothing being said regarding the candle-power of the lamps, contractors might think that in some way the insulation should depend upon this. But, strange to say, this rule of the Phœnix Fire Office is the most rational one we know, because it recognises the exact condition of things in practice. It fixes the insulation at the same figure for all voltages, realising that, for reasons we have given, the insulation is not made proportional to the E.M.F. It settles that for the maximum of 200 volts a certain insulation is sufficient, and argues that there is no object to be served in reducing it when the voltage falls below this. Prof. Jamieson objects to the rule on the ground that it ties the contractor down to the same insulation for 200 volts and 50 volts, and we are prepared to admit that, so far as actual acquirements go, an insulation is not required so high in the latter case as in the former. But how is the Professor to modify a 100-volt circuit that its insulation may be for 50 volts equal to one-half or whatever it is of its former value? Is he going to alter all the fittings or only the covering of the wire? Is he to make bad joints or subject the whole system to the influence of a Glasgow mist? We do not know, and we repeat that, in practice, the condition of things is not such as to enable the Professor's rule to be carried out, believing that it is false economy to purposely decrease the insulation of the system because the voltage happens to be lower in one case than the other.

The author of the paper has this further objection to the Phœnix Rule, that it does not give any candle-power for the lights; but in practice, the insulation resistance is, of course, independent of the candle-power. The leakage depends upon the number of branches, the number of fuses, switches, and lamp-holders, not upon the currents the particular branches are carrying; and the rule may be therefore held to correctly meet the requirements of practice. The question asked by Prof. Jamieson—"Should not the insulation resistance bear some definite proportion to the current?" can be answered only in one way. That it *should* there is no doubt, if it would only consent to be governed by the rules which are laid down for its guidance; but that it *won't* or *can't* is equally apparent, when we come to regard it in an everyday common sense light. The insulation resistance of every incandescence installation necessarily consists of a small part which may be increased with the voltage, and a large part which may not.

During the discussion, but two speakers referred to the matter of the paper, the others contenting themselves with sundry remarks concerning the method of making joints, &c. It seems to be the practice in some quarters to insulate the joints of rubber-covered cables with Chatterton's compound, which consists mostly of gutta-percha. Such practices cannot ensure good work, and the sooner they are discontinued, the better for all concerned. One speaker very sensibly laid stress on the fact that the lasting power of the insulation was of the utmost importance. According to him, the quality of the work was not to be judged by tests made immediately upon completion of the installation, but upon the insulation maintained after years of hard work. With this remark we most cordially agree, but to ensure this maintenance, the materials should be of the best quality.

We wait to see whether, at the adjourned discussion, anything of value will be elicited, but we have little hopes. Our opinion is that, of carefully drawn up impracticable rules, we have had enough. There will doubtless be considerable latitude allowed as regards insulation resistance, and many installations failing to reach what we should call a good insulation, we should hesitate to pronounce as bad. We think with Prof. Jamieson that at no time should the leakage current be more than $\frac{1}{10000}$th of the total current. With an insulation resistance allowing no greater leakage than this, safety will always be secured.

THE New York *Electrical Engineer*, in referring to a recent leaderette of ours anent a threatened corner in transformers, says:—"It is not difficult to identify one of the parties alluded to as the owners of the Paul Jablochkoff patent of 1887; nor does it require an excessive amount of Yankee 'cuteness to guess that the other is the so-called Grosvenor Gallery Syndicate." This last shot of our esteemed contemporary is not a bull's eye; indeed it is wide of the mark, but we do not mind informing our trans-Atlantic friend that the Anglo-American Brush Corporation was the other well known company to which our mysterious reference was directed.

WE congratulate both Prof. Ayrton and our contemporary the *Electrical Engineer* on the success which has attended the enterprise of the latter in bringing out in its last issue a portrait and biographical notice of the now popular Professor. Mr. Ayrton has posed for some years in a yearly publication, but in such a guise that his own mother could not have recognised him, and it is therefore with real pleasure that we can now look at a portrait which represents him most faithfully to the life, and which at the same time is an excellent example of art. The *Electrician* at the same time published a likeness and a similar notice of Sir William Thomson, but in this case, although the picture is an admirable specimen of the engraver's skill, the representation of that eminent electrician is not so faithfully pourtrayed. A lack of tone below the eyes give too full an appearance to the face; but nevertheless it is a capital production.

WITH reference to the recent action of the Institution of Electrical Engineers in banishing the Press from the general meetings of the Institution, we were much surprised to find one of our contemporaries calling us to account for having "divulged proceedings at the Council table which should have been kept private;" we are unable to see how information which at the time we published it was derived by us from more sources than one, and was the subject of common conversation, can be characterised as private. Our contemporary further says:—"There can be no doubt that indiscriminate reporting is not calculated to enhance the status of the Society forming the object of these reports. . . . On the contrary, it is likely to do harm. The perfect freedom to report, comment, and criticise may eventually engender a spirit of familiarity, and lead to the Press dictating to the Council in what way it should manage the affairs of the Society." Such an opinion as the foregoing we can only characterise as extraordinary; we submit that there is not a particle of evidence to indicate that the publications of the Press have ever had, or are likely to have, the tendency suggested, and to legislate for consequences which may ensue when there is no evidence whatever to prove that they are likely to ensue, is certainly foolishness. There is but little doubt that the Council of the Institution has been made a catspaw.

THE problem of central station lighting by electricity was said to have been solved in America by the system of divided mains, and these are some of the reasons put forth. Careful calculations in Philadelphia had shown that American data was to the effect that the total working cost of an 8,000-light station was only double that of 2,000 lamps. In other words, the cost per lamp in the larger station was only half that of the smaller; therefore, to make central stations commercially successful, they must be large. But, according to Mr. Gordon and his friends, a big output meant an extended district, and this, on the old direct-supply system, was impossible, owing to the prohibitive cost of mains, which, directly the distance exceeded a few hundred yards, increased the capital cost per lamp in a far greater ratio than the decrease of working expenses. Thus the possible percentage dividend decreased instead of increased as the plant became larger. By means of the Gordon method, however, it was gravely asserted that this order of things was reversed, and as the plant grew so the dividends became greater. As the limit to this wonderful growth of profit was not stated, we can only conclude that we have here a system going begging by which everybody could make a fortune if it were only properly applied.

WHEN Mr. W. H. Johnstone instructed Mr. J. E. H. Gordon that one of the most important duties devolving upon him was the compilation of a prospectus which the former was to circulate amongst local authorities, gas companies, and others interested in the great progress of illumination in the United States, he little thought how his carefully-wrought schemes would end. The terrible dangers involved in the use of the Gaulard-Gibbs transformer system have not yet torn Westinghouse to pieces, Edison has not been destroyed on the basis of expense, and the Gordon system has not been elevated to the highest possible pinnacle. Even though Mr. Gordon dealt with the scientific, practical, and mechanical part of the work, and Mr. Johnstone undertook the business side, we have not heard that the Gordon Electric Light Company of America has been the great success which the promoters anticipated.

IT was further added that the importance of the problem of central station lighting was shown by the desperate expedients devised to solve it, which were, however, being superseded by the divided mains. A company had even been started to employ alternating currents of 3,000 volts, and warning was given by the promoters of Gordon's American Company that the breaking of a wire meant setting buildings on fire and killing any person who received the escaping electricity. But right here comes almost the crowning point of all. Referring to M. Monnier's opinion, to which we alluded in our last issue, it was asserted that this report placed the Gordon system alone in the field as the only practical success. Furthermore, it was asserted:—"It is a common objection to electric light inventors to say 'Your invention is good to-day, but it may be superseded to-morrow.' *The Gordon system can never be superseded, as it can absorb and affiliate all the good points of future inventions.*" The palm of merit, however, must be awarded to the following fine example of Anglo-American contempt for George Washington and the precepts he tried to instil:—"As long as electricity is distributed through wires so long must the divided main system be used in preference to all others." Whether the delicious tit-bits which we have placed before our readers emanated from the scientific, practical, and mechanical genius of Mr. Gordon, or the commercially developed brain of Mr. Johnstone, we know not; they had, we believe, at least Mr. Gordon's assent, but the advocacy of the divided mains amongst the men of England and America appears to have met with the same fate as that which befell the divided skirt, rival claimants to the origin of which, we believe, are to be found amongst the fair sex of both countries.

THE circular letter which the genial secretary of the Institution of Electrical Engineers sent the round of the technical press was published *in extenso* in *Engineering* last week, and we were much gratified to see that great leader in technical journalism express its views on the situation in similar terms to those which had previously appeared in our own columns. We scarcely anticipated that the motion of Mr. Gisbert Kapp would have been supported in certain quarters; but it appears that everything in this life is carried on by a system of wheels within wheels, and to those who like to seek the causes which produce given effects, we would commend the study of the list of shareholders in *Industries*.

ON THE DIFFICULTIES IN THE WAY OF TRANSMITTING POWER BY ALTERNATING CURRENTS.*

By ALARD DU BOIS-REYMOND.

THE competition between alternating and continuous currents may be called a race between the alternating current motor and the accumulator. Although it is notoriously dangerous to predict what will be done and what will not be done, in this case, at any rate we may say so much: whereas the transformation of continuous currents, either by mechanical or else by chemical means, is to a great extent untrodden ground, which still may yield unlooked for discoveries, the use of alternating currents has been so thoroughly investigated in the laboratory as well as out of doors, that we may form a pretty fair conclusion concerning the boundaries to which we may still hope to push technical progress. I therefore propose to draw a sketch of the work that has already been done, and to try to define the boundaries, fixed by the nature of the problem of transmitting power by alternating currents, making use of the few publications that exist on the subject and of experience gained by a great number of different experiments which have been executed in the works of Messrs. Siemens and Halske, of Berlin.

Ordinary Dynamo with Laminated Field.

Ever and anon in technical literature we encounter the proposal to run an ordinary continuous current motor with laminated field magnets by alternating currents.

Whoever tries the experiment will meet with the following phenomena:—

1. Sparking cannot be avoided by any adjustment of the brushes.
2. The iron contained in the motor heats so quickly that the output must be kept a good deal lower than it would be were the same motor run by a continuous current.
3. The output depends upon the potential difference at the terminals of the motor.

The *rationale* of these phenomena may be given as follows:—

The use of an ordinary collector is necessarily connected with a short-circuiting of those two armature coils which belong to the bars touched by the brushes. If, therefore, the number of lines of force contained by these coils changes while the short-circuiting lasts a current is induced, the rupture of which causes a small arc to form as soon as the brushes pass on to the following pair of bars.

How far are the conditions for such a change in the number of lines fulfilled? When the position of the brushes is correct (fig. 1) the lines of force in the armature are at very nearly right angles to a straight line connecting the brushes. The pole pieces induce one component field, the direction of which is illustrated by the dotted horizontal line, fig. 1, coinciding in direction with their own position, the armature currents giving rise to the second coinciding with the position of the brushes, represented by the other dotted line. The resultant field comes in somewhere between them.

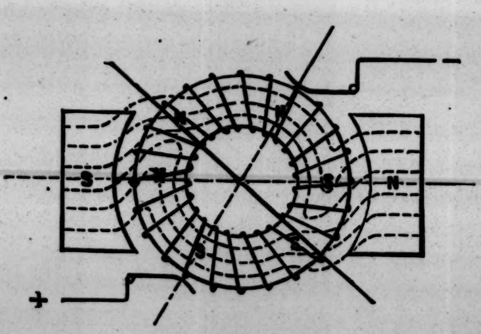

FIG. 1.

In a continuous current motor the magnetisation of the armature iron is only altered by the rotation of the armature, so that the number of lines only changes in those coils which pass through the resultant poles in the armature. If, therefore, the brushes are nearly at right angles to the resultant field in the armature, there is no reason for sparking in such a motor. Now, if you run the same motor with an alternating current, the magnetisation of both armature and field is continually changing. Look at any armature coil while the armature is kept at rest. The number of lines passing though it increases, decreases, changes direction, again increases, decreases and so on with every alternation. Were all coils short-circuited currents would be induced in every one of them, except in those the plane of which coincides with the direction of the force lines. But those coils, as we have before seen, are the very same in which currents are induced, as soon as the armature moves. It follows that whatever position you may give the brushes there must always be sparking, and the sparking will increase with the output, because with the output the magnetisation will increase.

For the heating of the iron two causes may be adduced, namely, the eddy currents and magnetic friction.

The suppression of the eddy currents is simply a question of design. If the field magnets are properly laminated, and the other metallic parts so disposed that they remain practically inductionless, the heating caused by eddy currents ought not to be appreciable. Nevertheless eddy currents will always remain a small source of loss.

But the quick heating of the iron, which is the principal cause of small efficiency, is mainly due to magnetic friction. Now it is well known that in a good transformer the energy dissipated by magnetic friction is only a few per cent. of the total output; why, therefore, should it be different in a motor?

In a transformer the ampère turns in the primary and secondary windings are very nearly equal, and the secondary current lags behind the primary by nearly half a period. Without committing a great error, we may say: The secondary ampère turns are equal to the primary and oppositely directed. It follows that the secondary current will neutralise the magnetising effect of the primary, and that the iron will be very nearly demagnetised, although the transformer works at full load. In other words, if you add the primary and secondary current, only a very small part of the primary remains to be employed for the magnetisation of the iron. In the motor, on the other hand, the whole existing current is employed for magnetisation, which is therefore very much higher than in a transformer of equivalent output.

The last-named phenomenon, namely, that the mechanical output depends on the terminal pressure, has not been mentioned before this, as far as I am aware. I will therefore take the liberty of discussing it slightly more in detail.

I imagine a conductor bent in a circle, the ends of which are connected with the terminals of an alternating current machine. The atmosphere surrounding the conductor may at first be an absolute non-conductor of magnetic lines of force. The current in the conductor will then simply conform to the law of Ohm. If a sine curve represents the variation of the potential difference at the termimals of the conductor, the current will be represented by a sine curve of the same period, the amplitude of which is solely dependent on the resistance of the conductor. If I now suppose the atmosphere surrounding the conductor to consist of wrought iron, which, for the sake of simplicity, may be absolutely subdivided so as to eliminate altogether the influence of eddy currents, a magnetic field will now be created, the direction and density of which follows the alternations of the current. Besides the potential difference at first existing at the terminals, we now will have a secondary pressure induced in the conductor, which is at all times proportional to the rate of variation of the magnetic field, and the amplitude of which depends on the magnetic resistance of the atmosphere, supposing the terminal pressure and the resistance of the conductor to be given.

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* Paper read before the Elektrotechnische Verein of Berlin, December 18th, 1888.

I make use of the graphic method at first devised by Thomson and Tait for the representation of periodic functions, lately employed by Mr. Kapp and others. The length of polar co-ordinates stands for amplitudes, the angles between them for differences of phase. In fig. 2, O M represents a wave, the amplitude of which is proportional to the magnetising current, C, and to the resistance, R. If we neglect hysteresis, the wave of magnetisation would have the same phase as O M, while the amplitude of this wave will depend on the quantity of the magnetising current.

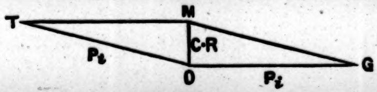

Fig. 2.

Proportional to the rate of variation in the number of lines is the induced pressure which, therefore, lags behind the wave of magnetisation—or, if we neglect hysterises, behind the curve representing C·R—by an angle of 90° C.R is simply the true loss of potential in the conductor or that potential difference which, in the above assumed case of infinite magnetic resistance of the atmosphere would be needed to give rise to the current, C, according to the law of Ohm.

Now we know that at present two different alternating pressures exist in our conductor, the terminal pressure and the induced pressure. A necessary condition for the existence of the current, C, of that size and in that phase, is that C·R shall be the resultant of these two pressures. We therefore find the terminal pressure by drawing a parallelogram (fig. 2) with O G (P_i induced pressure) and O T (P_t terminal pressure) as sides, and O M (C.R true loss of potential) as diagonal. You now see that given the resistance of the magnetising conductor, given the magnetic permeability of the atmosphere, and given the rate of alternation, a dependence quite different from Ohm's law exists between the terminal pressure and the magnetising current or between the terminal pressure and the number of lines created.

How can we increase magnetisation without increasing terminal pressure?

We know of no material which is a better conductor of magnetism than wrought iron, but we might increase the section of iron surrounded by our conductor. Supposing the magnetising current to remain the same the number of lines would then be increased. But we have seen that the secondary pressure depended on the number of lines. Therefore the secondary pressure would increase likewise. If you look at our parallelogram of pressures you see that, taking the terminal pressure, P_t (O T, fig. 2), as constant this is only possible if C.R has diminished at the same time. Now as the magnetising current, C, was also to remain constant, our assumptions will fail, if R has not decreased. But the contrary is the case, because the conductor has been lengthened in order to increase the section surrounded. The only result, therefore, which we have obtained by increasing the surface of the winding is to weaken the field and still more to weaken its density.

The resistance of the conductor would decrease if we diminished the section thereby surrounded. But then, if the number of lines is to increase, their density must increase still more, and saturation will at a certain point put a stop to increase of density of lines.

You see that variation of the section surrounded by the winding does cause variation of the field, but at the same time you will see that one certain section will be best, or, in other words, that given a certain terminal pressure the number of lines cannot be increased beyond a certain limit by altering the section contained by the winding.

Another plan would be to increase the section of copper in the winding, whereby C·R might be diminished without diminishing C. But this way is cut off in practice, because everybody will design the section of copper as large as possible to begin with. Besides, if we give this diagram (fig. 2) dimensions as they occur in actual practice, O M would be very small compared to O G and O T.

Till now we have been looking upon the number of lines of force as depending on the quantity of the magnetising current, but in reality it depends on the number of ampere turns. We might, therefore, connect a number of turns in series. That too, is of no use. You see in the diagram that P_t must necessarily be larger than P_i. You also see that taking C.R. as it is in reality, small compared to P_t and P_i, P_t, even for one single winding, is very nearly as large as P_i. If I now take N turns to my coil, it is true that C.R. would only be $\frac{1}{n}$th of its former value in order to produce the same number of ampere turns. But the same number of ampere turns will make the same field, and therefore P_i will be the same as it was before for every single turn, and as P_t must always be larger than P_i in every single turn, the total pressure at the terminals of the coils will be now something like N times its original value. *Vice versâ* it follows that given the terminal pressure by using N times the original number of windings in the coil the number of lines will not be increased, but will be diminished in a proportion very nearly equal to 1 : N.

What follows for the use of a laminated field dynamo as an alternating current motor is this. The output of any electro-magnetic motor evidently depends upon the size of cross section and the density of the magnetic field—*i.e.* on the number of lines created therein. Now, if the number of lines be dependent on the terminal pressure, the output must also depend on the terminal pressure. In other words, we come to the conclusion that to create a definite number of horse-power by running an ordinary dynamo with alternating current we shall want a certain minimum number of volt alternating pressure at the terminals of the motor.

Transformer-wound Dynamo.

We have seen that an ordinary dynamo used as alternating current motor differs from a transformer in this point. While in the transformer by far the greater part of the work which would be dissipated by magnetic friction, if the magnetisation corresponded to the number of ampere turns in the primary alone, comes out as electrical work at the terminals of the secondary, in the motor no demagnetisation of the iron accompanies the output of work. Naturally then the idea presents itself to make a transformer of the ordinary dynamo by short-circuiting the armature and allowing the primary current to flow through the field windings only. Thus at first sight we might expect to get a strong primary current in the field, and also a strong secondary current in the armature, without incurring a greater percentage of loss by magnetic friction than in a transformer. Mr. Rankin Kennedy, in his treatise on "The distribution of electrical energy by alternating currents and transformers," and Dr. L. Duncan, in his paper on "Alternating current electric motors" (read before the American Institute of Electrical Engineers, February 14th, 1888), have mentioned this plan as "Professor Thomson's motor," without entering into any detail on the subject. Some time ago Messrs. Siemens and Halske of Berlin caused a number of experiments to be executed at their works to ascertain the merits of this form of motor, which they call the "transformer-wound."

If you send an alternating current through the field windings of an ordinary dynamo, in the armature two electromotive forces will be induced which oppose each other. The direction of the arrows (fig. 3) shows the direction in which currents would be propelled, supposing the windings represented a right hand screw, if a number of the armature coils were closed (the brushes being supposed to be missing at first). The unit of length of arrows stands for a certain number of windings, or for a corresponding number of volts. The points of lowest and highest potential coincide with the poles induced in the armature by the alternating field. Now, suppose a pair of brushes to be connected by a sufficiently stout conductor and to touch the collector in these two points. Then a current generated by the two opposed E.M.F's. in the armature would flow through the armature windings, and return through the conductor connecting the brushes. But there would be no cause whatever to disturb the mechanical equilibrium of the system. This state of things, however, is altered as soon as we alter the position of the brushes. Pray consider, for instance, in fig. 4 the upper right half of the armature. There you have three-quarters of the upper arrow and about one-quarter of the lower one. This one-quarter piece is opposed to the three-quarter piece as to direction, but as length units of arrow are proportional to units of pressure generated in the windings of the armature, the opposed one-quarter piece will neutralise only a one-quarter piece, and a full one-half piece will remain, the pressure generated therein sending a current through the windings, and the connecting conductor in the direction indicated by the upper arrow. In the lower right half of the armature exactly the same process takes place. In fig. 4 the neutralised parts of the arrows are drawn with dotted lines. The two efficient quadrants of the ring are still perfectly symmetrical in relation to the pole pieces, but the currents traverse not only the generating windings, but also the neutralised windings, thereby twisting the field more or less, so that now all conditions for the creation of a rotatory movement of the armature are fulfilled.

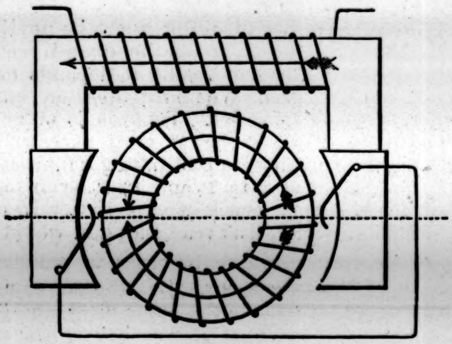

FIG. 3.

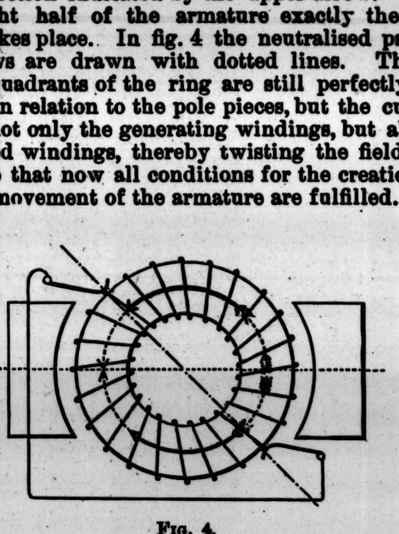

FIG. 4.

The question now arises, How far have we succeeded in eliminating loss of work by magnetic friction? First thing, we are forced by practical considerations to give up one very essential feature. Our motor still differs from a correctly designed transformer, in that the primary and the secondary coils are not in the same position relatively to the iron core. Our motor only resembles a transformer wound in the manner represented in fig. 5. In such a transformer there would still be a large dissipation of energy, for if, according to the above rule, we take the primary and secondary ampère turns as equal and opposed to each other, the result would not be demagnetisation of the core, but simply the formation of free poles at the ends of the two windings, marked respectively N and S in fig. 5.

But even if we had ideally fulfilled this condition, if, for instance, we employed one of those types of dynamo in which the field windings surround the armature and the field iron enwraps the whole, we should have gained nothing in this respect. Just as much as ever the output of the motor depends on the number of lines created therein, or, what is virtually the same thing, on the pressure created at its terminals. The energy seemingly saved by demagnetisation of the iron is solely employed for the greater or less twisting of the field, whereas every unit of magnetisation which is to come out at the pulley as mechanical force, has to be created over and above the twisting.

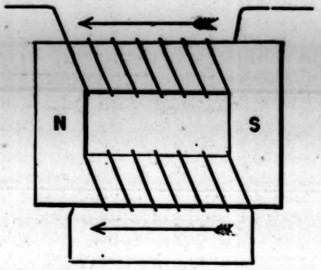

FIG 5.

Nevertheless, we have after all gained certain advantages. Considering that the output is a function of the terminal pressure, it will readily be admitted that it is better to have none of the primary current passing through the brushes. Moreover, the above-mentioned experiments have shown, what could not readily be anticipated, that while the efficiency of a transformer-wound motor is very nearly as good as that of the same motor series-wound when run by alternating currents, the sparking is altogether insignificant. Of this truly remarkable fact the following explanation has suggested itself to me. As the brushes pass over the collector they short circuit every armature coil in its turn. But as the bars move on the short circuit is not really disconnected; the coil is only opened out into the rest of the armature winding. Supposing, as is generally the case, that the current at this moment traversing the rest of the armature coils widely differs as to quantity and direction from the current induced in the short circuited coils, a shock is sure to take place as each bar passes the brush and a small arc is the result. Now in this case it is easy to see that the remarkable condition is naturally fulfilled that the current induced in the rest of the armature always has the same direction as the current induced in the short circuited coils and, moreover, has very nearly the same quantity, the only difference resulting from the additional resistance of the neutralised part of the winding, which in reality is smaller than the drawing, fig. 4, would make believe, owing to the twisting of the field. Hence, I believe, the absence of sparking.

Having so far become familiar with the different phenomena accompanying the use of the ordinary dynamo as an alternating current motor, we can now with comparative ease overlook the results obtainable from other windings.

By inverting the pure transformer winding, *i.e.*, by allowing the primary current to traverse the armature only, we evidently gain nothing. If we leave the field windings open, the only efficient cause of rotation will be the attraction of the poles created in the armature towards the iron of the pole-pieces. If we short-circuit the field windings, the secondary current generated therein will tend to demagnetise the field, *i.e.*, to diminish the output, while the heat generated by this secondary field current will be so much energy lost.

Pure shunt-winding presents the great difficulty, that it will be next to impossible to make the phases of the field and the armature currents coincide. This would only be the case if we made the induction of the field perfectly equal to that of the armature, a condition not only extremely difficult to fulfil, but altogether unfavourable to the obtaining of a reasonable output.

The different possibilities of mixed windings are hardly of any interest, except perhaps in so far as there are three different kinds of coils to compose a winding instead of two, as in the continuous current dynamo, namely, direct current coils, shunt coils, and secondary coils. But there are, in fact, fewer really distinct possibilities than you would imagine at first sight, and the phenomena of induction and interference become so intricate, that we cannot here enter into any detail, especially as no real advantage is gained by any of these windings, the general rules above developed for the pure series-wound dynamo being applicable to every one of them.

We may, therefore, leave the ordinary dynamo and proceed to consider another class of alternating current motors, namely the synchronous motors, of which the best representative is the ordinary alternating current machine used as a motor.

Synchronous Motors.

Dr. Hopkinson was the first to show that when two ordinary Siemens alternators are coupled in series, the one being driven by an engine, it is sufficient once to give the other one the same speed as the first in order to make it act as a motor. I will now show that by making use of Thomson & Tait's graphic method we can dispense with the rather voluminous formulæ of Dr. Hopkinson. I imagine two ordinary Siemens alternators coupled in series. For the sake of simplicity both machines may be perfectly alike and their fields may be excited by the same current. Next I suppose that both armatures may revolve with equal velocity. Then in both armatures will be generated equal electromotive forces, and the phases of these two electromotive forces will correspond exactly to the phases of the two armatures. You see that now our enquiry is resolved into the question—How do the different quantities vary, when the difference of phase between the two electromotive forces varies. This question may be answered by the diagram. We are free to fix in any position E_1 (O A, fig. 6) the electromotive force of machine No. 1, because we only have to consider the difference of phase. At first we will assume some definite difference of phase in order to have something to start from. I therefore draw E_2 (O B, fig. 6) lagging somewhat behind E_2, but of the same size. As both electromotive forces are generated in the same circuit they will be superimposed, and will compose a resultant electromotive force E (OC, fig. 6) which I obtain by drawing the diagonal of the parallelogram formed by E_1 and E_2 (O A C B, fig. 6). On the size and position of this resultant electromotive force, E, on the resistance of the whole circuit, R, and on the inductance of the whole circuit, which may be defined by the angle of lag, θ, will depend the size and position of the current, C. The real loss of potential, C . R, will, as above, be a resultant from the component electromotive force, E, and the induced secondary electromotive force, E_s. The parallelogram containing C . R as diagonal is therefore defined by the length of E, by the rule that the secondary electromotive force must lag behind the current by an angle of 90°, and by the assumption of some definite lag, θ, between E itself and the current (O C D F, fig. 6).

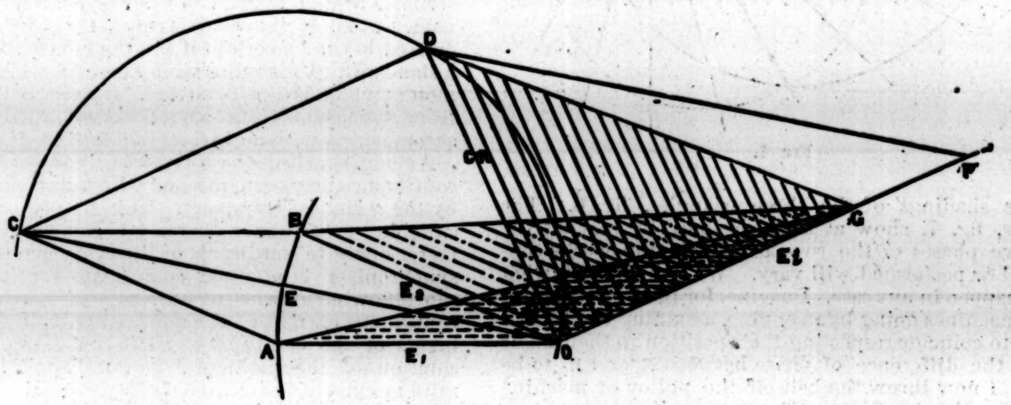

Fig. 6.

We must now find a method of graphically representing the work performed or consumed by our machines. There will be three different works extant in our system.

1. Production of heat in the circuit,equal to $C^2 . R$.
2. Work done by machine No. 1 equal to $E_1 . C . \cos\phi_1$, if ϕ_1 represents the angle of lag between the electromotive force of machine No. 1 and the current (A O D, fig. 6).
3. Work done by machine No. 2 equal to $E_2 . C . \cos\phi_2$, if ϕ_2 be the angle of lag between E_2 and C (B O D, fig. 6).

The sum of these three works must be zero. If we call work produced positive and work consumed negative, then three cases are possible.

1. $E_1 . C . \cos\phi_1$ is negative and $E_2\, C . \cos\phi_2$ is also negative, and both put together are equal to $C^2 . R$. Then both machines act as primary machines, helping each other to produce the current C.

2. Either $E_1 . C . \cos\phi_1$ is negative and $E_2 . C . \cos\phi_2$ positive, or *vice versâ*, the positive work added to the current heating $C^2 . R$ always being equal to the negative work. Then one of the machines—namely, the one whose work is negative—acts as primary machine, the other as motor.

3. $E_1 . C . \cos\phi_1$ is zero, and $E_2 . C . \cos\phi_2$ negative, and equal to the current-heating $C^2 . R$, or *vice versâ*. Then one of the machines—namely, the one whose work is negative—does all the work of current production; the other machine only turns without producing or consuming any work whatever.

It will easily be seen that if E and C be polar co-ordinates containing an angle ϕ, by giving any one of the two co-ordinates a turn of 90° in either direction, and then connecting their free ends, we obtain a triangle which is equal to $\frac{E . C . \cos\phi}{2}$.

The resistance of the whole circuit, R, we may take equal to one, this only being a question of proper choice of units. Then the corresponding construction of the three works in our diagram will be to measure off O G equal to O D (fig. 6) on O F, and so connect D, B, and A with G. Then the triangle A O G represents the work of machine No. 1, the triange B O G the work of machine No. 2, and the triangle D O G the current-heating lost in the circuit. I give the different triangles different shadings, and you now see that we have by chance hit upon case No. 1, in which the works of both machines are negative—*i.e.*, both machines combine to produce a current.

The following diagram, fig. 7, is obtained by keeping E_1 in a fixed position, O A, and turning E_2 over the whole period from 0° to 360°. By measuring out from the centre O on E_2 in a sufficient number of its positions three lengths proportional to the three works belonging to those positions of E_2 we obtain the three curves distinguished in fig. 7 by different dottings, corresponding to the shadings of the three triangles, fig. 6. The curves, fig. 7, show at a glance how, by varying the relative phases of the two armatures, the works consumed or performed will vary. We can predict what will happen in any case. Imagine, for instance, that I set both machines going by an engine, assuming their armatures to coincide respecting their position in their fields —*i.e.*, the difference of phase between E_1 and E_2 to be zero. I now throw the belt off the pulley of machine No. II. You see that in this position of the armatures the works of both machines are negative and equal to each other, the current heating is a minimum. The result will be that machine No. II. must fall back. As it passes through the different positions on the upper half of the diagram more and more of the energy stored up in its rotating armature is consumed for the production of current, till at B_1 (fig. 7), the work performed by machine No. I. sinks to zero, and then even becomes positive. But the moment E_2 passes an angle of 180°, namely, at D, the work of machine No. I. once more becomes negative, and the current heating, together with the work of machine No. II., is equal to it; in other words, machine No. I now acts as a motor.

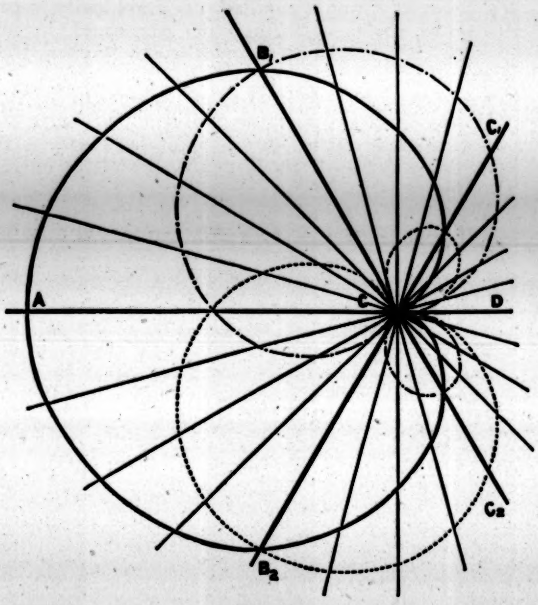

FIG. 7.

I now put a brake on its pulley, and begin to take mechanical work out of it. It will again fall back, but only to such a position as to balance the output by the work it now receives from machine No. I. If it were to fall back any further it would evidently receive more work than it produces, so that its speed would be increased, thereby diminishing lag till work consumed and work produced were exactly balanced.

It will be remarked that in this part of the diagram the action of our machine is perfectly analogous to that of a continuous current motor run at constant pressure. By increasing the load on the brake you increase the output, and you increase the current, thereby making an alteration in the position of the brushes desirable, corresponding to greater lag in the alternator.

But as I go on increasing the load, you see that a maximum output is reached at a certain point, O C_2, which if I once overstep, the equilibrium between output and load will henceforth be destroyed, because from this point onwards the work machine No. II. is capable of producing diminishes. When the angle of lag, θ, between the resultant electromotive force, E, and the current is assumed to be 60°, then at a difference of phase of 240° between E_1 and E_2, this maximum is reached. At the same time, $\theta = 60°$ gives us the maximum output attainable from the system described. In the drawing (fig. 7), I have assumed this angle. You see that at the point of this maximum the work received by the secondary machine is equal to the current heating in the whole circuit. Therefore the maximum output of an alternator used in this way as a motor is exactly half of what it would be if you used it as a primary machine. If we call "efficiency" the quotient of the electrical work measured at the terminals of the motor into the mechanical work measured at the brake, then taking the current-heating in the line to be zero, we should have theoretically an efficiency of two-thirds at the point of maximum output, or of 66·7 per cent., and the efficiency would increase as the load diminishes, because the work lost by the production of current in the circuit decreases quicker than the work received by machine No. II. The output of the motor, considered apart from the rest of the system, would increase if we used a smaller machine than the primary only with Siemens alternators, in that case the speed of the motor would grow beyond the limits of practicability in order to reach synchronism. But the greatest drawback to this system of power transmission is the circumstance above described, which attaches to all synchronous motors, namely, that if the load is even for a short time increased beyond a certain limit, the motor will come to a standstill. This rule also applies to those synchronous motors which are self-starting, because the transition from synchronism to asynchronism will always be accompanied with a considerable falling off of output.

Among synchronous alternating current motors the contrivance may be mentioned which has been patented by the "Helios" company. This simply consists of a suitable commutator-device so connected that the motor ought to start as an ordinary dynamo, and when synchronism is attained commutate for its own use the inflowing alternating current. If it really made a continuous current of the alternating, as the advertisements of the company state, it would be next to a solution of the problem; but, unhappily, an intermittent current is far from being equivalent to a continuous current, so that in this motor we have most of the inconvenience of synchronism combined with most of the inconvenience of alternating currents, without any appreciable real advantage. Besides, with an alternating current of 70 complete cycles per second, certainly a low number, this motor would have to run at 4,200 revolutions per minute in order to synchronise.

We may now turn to the most important, and, at the same time, the newest motor that has hitherto been brought forward.

Tesla's Motor.

The principle on which this motor is based was invented by Prof. Ferraris, of Turin, who calls it "electrodynamic rotation." Mr. Ferraris says:—"If A, (fig. 8) represents a component magnetic field, and B a second component magnetic field, then the resultant

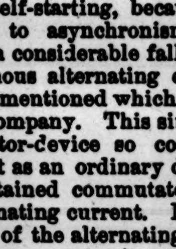

FIG. 8.

field, R, is the diagonal of a parallelogram, with A and B as sides. Therefore, by letting A and B vary, I can change, *ad libitum*, the position and size of R." Mr. Ferraris now enquires:—How must A and B vary, so that R remains constant and rotates round the zero point. This enquiry leads to the following result:—Let A vary as a sine of the time, and B as the cosine of the time, and let the angle contained by both be 90°, then the free end of R will move on a concentric circle, *i.e.*, the resultant field will rotate round the zero point without changing its intensity. Therefore, if I give two coils such a position that their magnetic axes are perpendicular to each other, I need only excite the one with an ordinary alternating current and the second with another alternating current, differing from the first only by a time lag of one quarter of a period, in order to obtain a constant rotating field.

This principle is employed by Mr. Tesla for the production of two types of motor, the synchronous and the asynchronous. Imagine the armature of an ordinary dynamo wound with only two coils at right angles to each other and the field excited by a continuous current. Then the rotating field in the armature will strive to coincide with the surrounding field, so that the armature once started will remain turning at a velocity depending on the rate of alternation of the driving currents. We obtain a synchronous motor mechanically identical with a continuous current motor as long as synchronism is maintained. But this motor will not start, and needs to be excited by a continuous current.

The second type of Mr. Tesla's motor is the one now built by the Westinghouse Company. In this motor the secondary armature is constructed in form of a Gramme ring with four coils (F, fig. 9), and serves as field magnet. It remains stationary, and inside it another armature, A, is caused to rotate by the action of the rotating field in the outer ring. If the inner armature was stripped of its windings, poles would be induced very nearly opposite the moving poles in the outer ring, the time lag caused by hysteresis not being very considerable. In that position of the active poles, the turning force of attraction being very nearly in a radial direction, is very weak. Mr. Tesla therefore surrounds the inner armature by an ordinary winding, which is short-circuited all round the collector. Supposing the inner armature not yet to have acquired synchronism, there will be a difference of speed between the rotation of the field and of the armature. We may as well consider the field to be stationary, and the armature to rotate backwards with a speed equal to the difference of the two velocities. Then we at once see that the whole motor is in principle an ordinary dynamo, the armature coils of which have been short-circuited, the result being that the field in the armature is twisted, thereby greatly augmenting its rotary momentum.

Now the question interesting us most is: How far does this motor fulfil the promise of the Westinghouse Company, that its efficiency is as good as that of a continuous current motor? In the first place we remark that the magnetic disposition is slightly worse than in a continuous current motor, because we have to find room for two windings instead of one between the field iron and the armature iron. This would be of no great consequence, but we may easily see that the work dissipated by magnetic friction must needs be a good deal greater than in a continuous current motor of the same output. Supposing both motors to have exactly equal armatures, and to work at equal speeds, then in order to produce in both the same torque, we will afford very nearly the same amount of magnetic friction in the armatures of both. Now in the continuous current motor, magnetic friction takes place in the armature only, whereas in Mr. Tesla's motor the twisting of the field in the armature is due to the difference of speed between the mechanical rotation of the armature and the magnetic rotation of the field. Therefore, in the Tesla motor, not only is the work dissipated by magnetic friction larger than that dissipated in the continuous current motor in proportion as the total quantity of iron is larger than the quantity of iron contained in the armature only, but in a proportion considerably greater still, because the speed of rotation of the field will have to be something like double the speed of the armature, in order to twist the field in the desired degree. You see that even the Tesla motor cannot compete with the continuous current motor for efficiency.

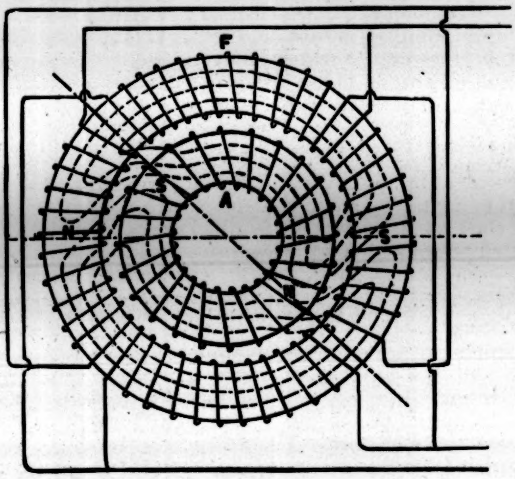

FIG. 9.

Its principal advantage is the comparative simplicity of its construction. You don't want a collector, and the power transmitting current is carried into none but stationary parts. But these slight advantages give way to a more serious difficulty. You want four, or, at any rate, three wires connecting your motor with the central station, and these wires may not be taken from the ordinary lighting wires, because they come from the transformer. Moreover, at the central station, special arrangements must be provided to generate two currents, one lagging behind the other by a quarter of a period. Nevertheless, it cannot be denied that these difficulties would become less important if a central station were planned and executed from the beginning for this Tesla system.

You see that not one of the alternating current motors hitherto extant approaches the desired ideal. How about the future of power transmission by alternating currents? One thing is evident. In every electro-magnetic motor there must be some connection between magnetic friction and efficiency, continuous current motors not excluded. Then if we see that continuous current motors have so much better an efficiency than alternating current motors, where is the essential difference between the two? In a continuous current motor, supposing the saturation to be constant, the work dissipated by magnetic friction is solely dependent on rotation. All other sources of loss being common to both, we need only consider the loss of energy by magnetic friction. Now in non-synchronous motors the amount of loss by magnetic friction evidently depends on two causes, the rotation of the moving parts and the rate of alternation. It is therefore impossible that non-synchronous motors can work with as little loss by magnetic friction as continuous current motors. Such a state of things would be approached if the rate of alternation were inappreciably small compared with the number of revolutions of the motor, a condition not to be fulfilled in practice.

In synchronous motors we have seen that the efficiency depends on the phase which the armature will assume according to different loads. There would therefore be no reason why we should not be able to construct a synchronous motor, which with a suitable load might yield as large an efficiency as a continuous current motor of the same output. But the practical difficulties necessarily connected with synchronism in any form such as the difficulty of starting, the smallness of variation of load allowable, &c., are more important than it seems at first sight, when you remember that the alternating current motor has not only to demonstrate its capability to live, but has to compete with the continuous current motor.

The comparison of efficiencies brings out another difference between the two. Mr. G. Kapp in his paper on alternating current transformers well distinguishes between "efficiency" in the ordinary sense of the word *i.e.*, proportion of output and energy consumed and "plant efficiency" which may be defined as the amount of output obtained from the unit of capital laid out. In a continuous current motor this would be the same thing as by $\frac{W}{P_t C}$, W being the work measured at the pulley, P_t being the terminal pressure, and C being the current, the quantity of C and therewith the size of leads is determined as soon as we have decided on some definite pressure.

On the other hand, with alternating currents $\frac{W}{P_t . C . \cos\phi}$, ϕ being the angle of lag between P_t and C may apply to any number of ampères, the number of volts, and the number of watts remaining constant. Now, this angle of lag, ϕ, will, generally speaking, vary with the output the motor is designed for, and will at any rate never be zero. That is to say, even if we had constructed the ideal alternating current motor, with as large an efficiency as a continuous current motor, it still would consume more current than the continuous current motor, pressures being equal. In other words the mains would have to be made stouter, or the plant efficiency would be less.

Time will show whether the advantages, which without doubt the alternating systems possess, compared with the present state of continuous current work, will be able to outweigh the difficulties which I have endeavoured roughly to sketch within the narrow limits of this paper.

Before I conclude, I have to thank my friend, Mr. H. Görges, for the very valuable help which he has rendered me, especially with respect to the graphical representation of the alternating current machine used as a motor.

SIX YEARS' PRACTICAL EXPERIENCE WITH THE EDISON CHEMICAL METER.

By W. J. JENKS.

(*Continued from page* 92.)

The meter case is made of well-seasoned hard wood, specially prepared to expel air and prevent warping, and to maintain high insulation, the door of heavy sheet iron being properly lettered and numbered. This is held closed by a metallic button turning upon a small post, both passing through a vertical opening. The wire of a lead seal is passed through the button.

The conductors enter and leave the meters through holes in the side or bottom, about two or three inches apart.

The thermostat is required for all meters situated in locations where the solution is likely to freeze. It is furnished as an extra attachment, and may be inserted in any sized meter, and to it is attached a small contact point connected with a lamp socket. Into this socket is screwed a lamp, and when the temperature in the meter falls below a certain point, will cause the thermo strip to curve up, bringing the two contact points together, closing a circuit through the lamp and heating the interior space. As the temperature returns to normal the strip straightens and the lamp is cut out. The adjusting screw in one complete revolution changes the elevation of the contact point $\frac{1}{48}$th inch, and being made with a six-sided head (numbered), one-sixth of a turn will change the absolute temperature standard of contact about 2° Fahrenheit. Thus the adjustment may be made sufficiently close.

The cells are partially filled with a 10 per cent. zinc sulphate solution, no special effort being made to render them air-tight, but to prevent evaporation. In these the zinc plates are supported by ebonite distance-pieces, screws and nuts, and connected by copper rods with spring clips fixed in the top of the space.

The resistance in the main circuit is of German silver, of the quality used by Elliot in his bridges, and so proportioned as to allow $\frac{1}{975}$th of the current to pass through the cell and its compensating spool.

The small portion of current passing through the bottle removes from one plate and deposits upon the other metallic zinc, which when its weight is ascertained determines the current transmitted.

The two-wire meters, authorised to be used with the three-wire system, are of two sizes only, 5 and 10 ampères capacity respectively. Anything larger than 5 ampères may be preferably divided to balance the two sides, and hence they are made of 5 ampères each side, capacity 20 of the present 16 C.P. lamps; 10 ampères, 40 lamps; 20 amperes, 80 lamps; 40 ampères, 160 lamps; 80 ampères 320 lamps. This will be made more clear by a table of size and capacity of meters :—

Meter No.	Maximum ampère capacity.	
0	5	2 wire meter for 5 ampères.
½	10	2 „ „ 10 „
1	10	3 wire meter for 5 amps. on each side.
2	20	3 „ „ 10 „ „ „
4	40	3 „ „ 20 „ „ „
8	80	3 „ „ 40 „ „ „
16	161	3 „ „ 80 „ „ „

In selecting the proper size of meters for certain customers, it is borne in mind that a meter plate has, like a storage battery, a somewhat definite maximum capacity in ampère-hours per month. The standard found most desirable is 150 milligrammes deposit per month per ampère of nominal capacity. The normal capability is therefore understood to be restricted to an average work of one or two hours per day at this maximum load, which corresponds with practical work. If steady work is to be done for an average of three to four hours daily, the load should be about 20 per cent. less; if from five to six hours, about 25 per cent. further reduction should be made, to determine the proper limit for a given plate.

The meter is in practice placed in all sorts of positions. The general instructions simply provide that it should be kept clean and dry inside the service fusible cutout, and easy of access.

The initial preparation of plates consists simply in thorough cleaning, covering the top and about an inch of the rod with a coat of asphalte varnish, amalgamating and drying (three coats when new), weighing and togging of the positive plate, and placing in the solution.

When removed the plate is reweighed, and where two bottles are used their weights are compared by the meterman, and his record sent to the book-keeper or superintendent.

The loss in milligrammes sustained by the positive plates is then multiplied by the meter constant, which gives the bill in dollars and cents. This constant is found as follows :—

Let \$ equal price of one standard lamp-hour.
C equal ampère capacity of standard lamp.

Then current through the bottle equals $\frac{C}{975}$.

As 1,224 milligrammes (of zinc) is represented by one ampère hour, one standard lamp is equivalent to $\frac{1{,}224\ C}{975}$ milligrammes, at the price, \$. Hence the price for current which has dissolved one milligramme of zinc will be :—

$$\frac{\$}{\frac{1{,}224\ C}{975}} \text{ equals } \frac{\$ \times 975}{1{,}224\ C} \text{ equals constant.}$$

Each consumer has a meter upon his own premises, and his bill is made out and payment required upon what the meter shows. To measure the current by means of a meter, and to do so with sufficient exactness to support a bill, the payment of which was to be insisted upon, at first seemed to many of the customers of our various companies an impossibility, and they accordingly resorted to various devices for the purpose of themselves testing the accuracy of the measurements. The most noteworthy of these, for the reason that it affords a simple and effective check, was to keep a record of the hours each lamp was in use, and by multiplying this number by the given rate of a 16-candle lamp per hour, to determine what the amount of the bill ought to be. There have been many instances where, in order to satisfy customers that the meters were reliable, we have taken their record at the end of a given time, during which the customer has kept an account of his lamp hours, and have presented bills upon what the meters showed, that the customer might check the amount of his bill by this simple rule.

Objections.

It has been argued that the Edison chemical meter, in its best estate, is open to several very serious objections :—

1. The necessity of the expense attending the removal and replacement of the bottles, usually at monthly intervals, and the complete disconnecting and weighing of their plates. So far from being a detriment, this is seen to be in the light of practice a positive advantage. A gas meter is adjusted once for all, and once placed is inspected only at long intervals, or when strongly suspected of inaccuracy, while the Edison meter receives thorough inspection and radical readjustment every month. The sources of error lie almost entirely within the bottle and are thus speedily corrected.

2. The necessity of employing what objectors are pleased to term a chemist as a meter man. In the early history of any art, until the conditions of practice became thumb rules, the manipulator of an important device should be a man of intelligence and some originality of ideas. After a time the work becomes simply a matter of routine, and the occasional oversight of the manager or other official will detect any irregularities. Thus it has been with this branch of our work. The most of our meter men are young, and receive only moderate pay, as the statement of cost of operation elsewhere given conclusively shows. Accuracy and caretaking in matters of detail are the prime requirements. The work has been greatly simplified by arrangements with Mr. Edison, by which electrolytic zinc plates (standard zinc) sulphate solution in carboys (or salt if preferred), distilled mercury and four simple reagents, for the testing of water for solution by such companies as prefer to prepare it themselves as a matter of convenience or economy, can be obtained. These reagents are : (1) Ammonia water. (2) Ammonia sulphide. (3) Nitrate of silver, and (4) Sulph. cyanide of potash. A few drops or a small crystal of each, as the case may be, to be added to separate portions of water. Any meter man can thus make the four simple tests (once for all) which by a precipitate or by cloudy colouration will show the water to be unfit for use.

Ordinarily ice water is available, and where this fails, a simple apparatus for condensing and distilling, costing $25, is sometimes desirable.

Sources of Error.

This brings us to the consideration of the real importance of the sources of error. Nothing that man has made is free from some of these drawbacks to accuracy, but when we except those mechanical imperfections common to all electro-mechanical devices, it is surprising how few appear which play any important part in the result, and how far these few are neutralised. In order to point the application of the few facts and diagrams to be shown, let us refer briefly to the criticisms made on this much-misrepresented, but important friend of the Edison manager.

From the English *Electrician* of December 16th, 1887 :—"Edison calculates the total consumption of current by passing a known (or supposed known) fraction of the total current through the meter and the energy supplied is calculated on the assumption that the difference of potential is constant throughout the circuit. This assumption is, of course, only approximately correct."

From the same journal December 30th, 1887 :—

"In the third edition of Sir David Salomons's work on the 'Management of Accumulators,' the author (on page 105), gives the following definition of Edison's meter :—'A thing of the past, depending upon the deposit of some metal.' We are unfortunately a little doubtful as to the immediate accuracy of the first part of this description, inasmuch as we are under the impression that this apparatus is still extensively employed by the Edison Company of the United States ; but in the light of the statements alluded to above there can be but little doubt that Sir David's description will sooner or later be perfectly accurate. As to the 'deposit of some metal,' which appears at present somewhat erratic, we suppose the balance is made up on the settlement of the account. But if these accounts have any foundation, it is perfectly clear that the error is entirely against the company. As we recently had occasion to remark in our articles on the Brighton installation, the Edison plan, by which a fraction only of the current supplied is measured, can be accepted as little better than a makeshift at the best."

One more quotation (from the *Electrical World* of a little more than a year ago, October 22nd, 1887), of some remarks made at one of the meetings of this institute. It is especially desirable to bear them in mind as an illustration of the idea that a little knowledge and a great deal of theory on any subject are dangerous things in the light of actual experience :—

"There has been already a great deal of time and a large amount of money spent on electric meters for direct currents, and I do not think we have had any current meters of any value whatever.

"The electro-chemical system in use by a very prominent company here was put out with a great deal of confidence with the results to be obtained from it. I think anyone looking at the principles involved would condemn it from the start. You are to take a small fraction of the total current, and a very small fraction indeed, and pass it through an electrolytic cell, the character of which varies from time to time, so that the resistance is never fixed, and pass the bulk of the current around a resistance which is practically fixed. The change in the resistance of the metal would be but a small proportion of the change in the resistance of the electrolyte. Now in such an instance as that you are measuring a very small fraction of the current passing, and whatever error you have are multiplying that error by the fraction. If you are measuring $\frac{1}{1000}$ you are multiplying your error by 1,000. Anyone who has had much to do with electro-metallurgy knows that the cells are constantly changing, that to keep the deposit regular and uniform, to keep the resistance of the solution uniform, they must be constantly attended to. There is not an electroplater in the country who does not once in a while go in and stir up his baths. Such an instrument is of no real value. We may therefore dismiss those instruments entirely from consideration I think.

"If anyone will take the record of the Patent Office on electric meters, he will see that there has been no small amount of time and thought and money spent on that question. Practically, we are in the same position we were before. We had nothing except the electro-chemical meter, which, as I say, I consider entirely worthless."

The lack of information on this subject, thus illustrated, will be seen more clearly by an analysis of the possible value of the sources of error.

Oxidation.

In the hands of an inexperienced person almost any method or device, good and reliable in itself, may be misapplied so as to gain an uneviable reputation. An Edison meter cell may be so manipulated as to measure almost any resistance, and vary between wide limits. A few practical rules have, however, been applied, and the bugbear which has so disturbed the visions of those who have looked at the matter from a theoretical standpoint only has disappeared. In other words, we are able to reduce practically to nothing this error, and it therefore appears in the results only as a slightly disturbing element at the lower end of the deposit curve, and always against the company.

The German Silver Shunt.

The extract I have read specifies quite distinctly the slight error introduced by the change of resistance of the German silver shunt with temperature variations. For each 25° centigrade, or 45° Fah., this variation is but 1 per cent. Within a range of 40° it is 0·0249 per cent. for each degree (Fah.). A shunt having 0·01 ohm at 60° Fah. would be—at 2° Fah., 0·00984; and at 100° Fah., 0·01009 ohms. The maximum error which can ever occur is about 2°, due to a change from freezing to 120° Fah., the maximum reached in any of the meters at full load. As a matter of practice meters are so placed as to vary not over 30° or 40° on the average, either from atmospheric changes or the heating of the counter electromotive force.

(*To be continued.*)

WILLIS'S ELECTRIC SHIP'S TELEGRAPH.

ALTHOUGH electric ship's telegraphs are by no means novelties, yet they never seem to have been practical successes, partly, no doubt, in consequence of faulty construction and partly in consequence of defective batteries. Till within the last few years the use of electric appliances on ships was comparatively rare, and, as a consequence, the amount of skill which is necessary to keep even the most simple apparatus in order was lacking, so that fault in the instruments, such as an empty battery cell, a loose connection, or a broken wire, practically meant a complete and permanent breakdown of the whole arrangement. At the present time, however, when every ship of any size is fitted with the electric light, electric bells, &c., the engineer or some of his staff (especially in the case of war ships) has considerable knowledge and experience of electric appliances, faults of the description mentioned are easily traced and put right, and practically cause little, if any, trouble, much less a complete breakdown; this being the case, the use of electric ship's telegraphs becomes perfectly practicable. The advantage of an electric over a mechanical system is very great from the point of view of cost, especially in cases where numerous and stout iron bulkheads are fitted to the ship, for this means for a mechanical telegraph a heavy expense in cutting holes for the passage in a direct line of the connecting rods and for the bearings of the same, and moreover to work the apparatus must, when the distance between the transmitter and receiver is great, necessarily require the expenditure of very considerable force. An electric system gets over all these difficulties, and it can be perfectly relied on, provided it is carried out on proper mechanical principles.

The apparatus (designed by Mr. J. Bonelle Willis), of which we give illustrations, is undoubtedly the nearest approach to perfection in an electric ship's telegraph that has yet been brought out, and it is a marvel of mechanical ingenuity.

The chief portion of the apparatus is that for transmitting orders between the bridge and the engine room, and in outside appearance it much resembles the ordinary well-known mechanical telegraph. The arrangement consists, as will be seen by figs. 1 and 2, at each end of a transmitter and receiver, which are practically duplicates of each other, the difference between the two merely consisting in the mounting and in the means of illuminating the dials, the latter being effected in the case of the instrument on the bridge (fig. 1) by lamps shining through opal glass on which the indications are painted, and in the case of the instrument in the engine room (fig. 2) by the light falling direct on the dial.

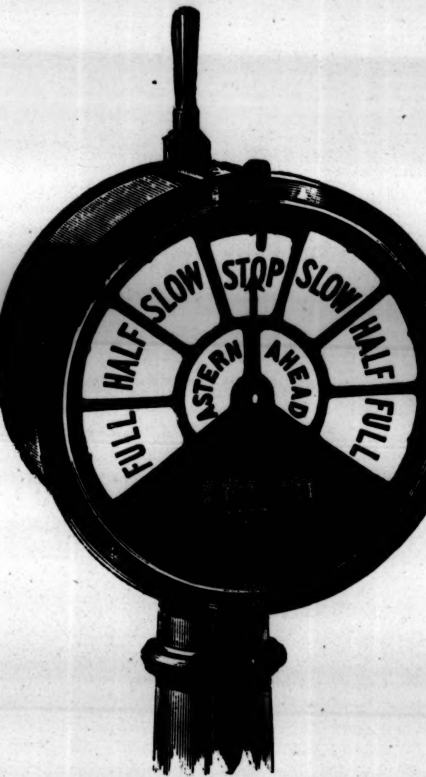

FIG. 1.

The transmitting part of each consists of a handle movable around a horizontal axis.

This handle is intended to be placed in positions corresponding to the signals to be transmitted, such as "stop," "slow," "half speed," and "full speed," both ahead and astern.

Upon the handle lever at a short distance from the axis a spring drum is carried; two chains pass around the drum and are led from it over guide pulleys and attached to a contact-making arm. This arm is also movable around the central stud or axis, and it carries a spring contact-piece, which bears against a stationary arc divided into a series of contact strips each separated by a small air space. Around the central boss of this contact arm gear-teeth are provided; these engage with a pinion, which through other toothed gear drives a fly. This fly restrains the movement of the contact arm and compels it to travel slowly; for the fly has to make many revolutions, whilst the arm moves a comparatively small distance. The chains which connect the contact arm with the drum upon the handle are directed by guide pulleys, so that the chains approach the contact arm from opposite sides. When the handle is moved to the one side the chain passing to the other side of the arm is strained, and but for the rotation of the spring drum the handle could not be moved. On the other hand, the chain on the side towards which the lever is moved is slackened, and would fall loose but that one of the pulleys over which it passes is movable and controlled by a light spring, so that this guide pulley moves and takes up what would otherwise be the slack of the chain. *Thus, however rapidly the handle may be moved from one position to another in order to transmit a fresh order to the engine room, the contact arm will follow only at its leisure, and at such a speed that the receiving instrument can act with* *certainty.* In addition to the parts already described, the transmitter also contains the following :—

The handle is provided with a locking bolt, which is lifted and released when the handle is gripped, and which when the handle has been moved to a proper position for giving a signal, drops into a hole in the base or frame as soon as the handle is released. This bolt locks the handle so that it cannot be moved, accidentally or otherwise except when it is gripped with the hand.

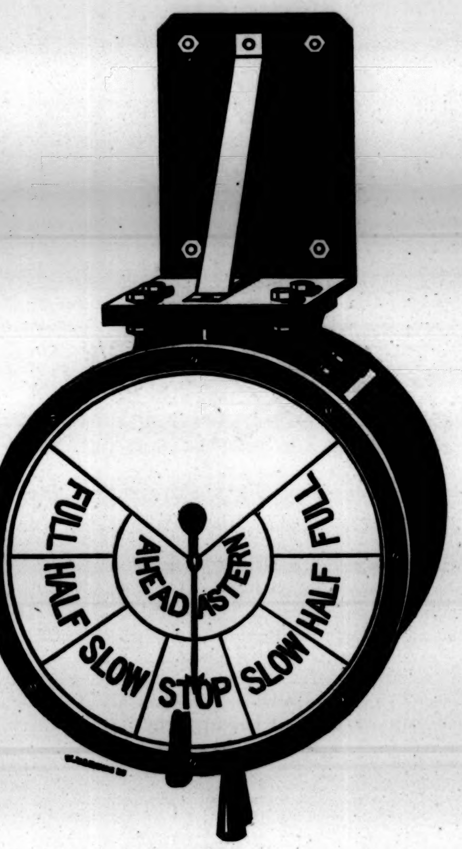

FIG. 2.

Fixed to the contact arm there is a disc, and in the periphery of the disc is a notch. When the apparatus is at rest the end of a small lever mounted on the handle drops into the notch. When the handle is moved to one side or the other to give a signal, the lever after being removed from the notch in the disc connected with the contact arm is carried with the handle away from the notch, so that its spring contact is continued after the handle is released, and until the comparatively slow movement of the contact arm brings it and the notched disc to such a position that the end of the lever can enter the notch, which a spring causes it to do immediately, and the circuit through the apparatus is then open. The circuit, so far as it is contained in the transmitting instrument, is traced from the line wire to the conducting contact strip on which the contact arm bears, through the contact arm and other parts to the contact spring of the lever on the handle, and so to the insulated metal arc on which this contact spring bears, and again to line. When the contact arm travels, it moves from one conducting strip to the next until it comes to a stop on one of these conducting strips, and the lever on the handle enters the retaining notch ; the circuit is then opened, and remains so until the handle of the signalling apparatus is again gripped and shifted to a new position.

The receiving portion of the instrument is provided with three electro-magnets, set around a central axis at an angular distance of 120° the one from the other. Each electro-magnet is provided with an armature movable around a stud or fulcrum at one end, and at the other connected by a rod with a pin set eccentrically upon a disc carried by the central axis.

Each armature when it is attracted thrusts the axis round a third of a revolution, and the magnets operating in due order, the rotation is maintained as long as may be necessary. The action, in fact, is very similar to that of a 3-cylinder steam engine. This axis is geared by means of a pinion upon it with a toothed wheel upon another axis, and this axis carries an index which points on a dial to the signals as they are received. The index moves one space, or the interval between one signal and the next, as each electro-magnet attracts its armature, and so one, two, or three steps can be made. For the fourth step, when this is required, the first magnet operates a second time in due sequence after the third magnet, and so by the magnets operating in regular rotation any desired number of steps, and in either direction, may be obtained. The transmitting instrument, it will be understood, is provided with a separate contact strip corresponding to each signal.

The main battery for working the apparatus is situate in any convenient position, and its circuit passes through one or other of the propelling magnets, through the corresponding contact piece in the transmitter, through the contact arm of this instrument, and so to the arc, with which the lever spring closes contact. This arc is permanently connected with the other pole of the main battery.

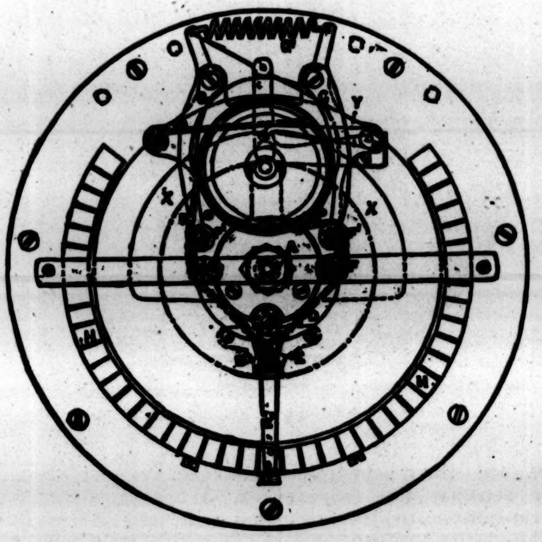

FIG. 3.

Fig. 3 shows a front elevation of the transmitting apparatus. A is a fixed central stud or axis, to which is fixed the handle lever ; C is a drum containing a coiled steel spring ; it is mounted upon a stud fixed into the handle lever. D, D, are fusee chains fixed to the periphery of the drum, C, and passing from it to the contact-making arm, E, to a stud, E^1, upon which they are attached. The chains are directed by guide pulleys, F, F^1, so that the chains are brought to the contact arm from opposite sides. The guide pulleys, F, F, are mounted on studs fixed into the handle lever, but the axes of the guide pulleys, F^1, F^1, are carried by levers, G, G, which are movable upon the handle lever, B, and a coiled spring, G^1, connecting the shorter ends of the levers, G, tends to separate the pulleys, F^1, F^1, and so to prevent the chains from becoming slack. E^2 is a spring contact piece at the extremity of the contact arm, E ; it bears constantly upon an arc, H, and this arc is made up of insulated conducting strips each separated by a small air space ; there will be one conducting strip for each signal which the instrument is arranged to transmit. The conducting strips are of brass, and they are connected with insulated wires passing from the transmitter to the receiver at a distance. There are three such wires in connection with these insulated strips, and whatever be the number of strips employed, the first, fourth, and the seventh strip will be connected with one wire, the second, fifth, and eighth with another wire, and the third, sixth, and the ninth with a third wire. Any greater or less number of conducting strips will be connected in a similar manner.

An arc of teeth carried by the contact arm, E, gears with a pinion, and on the same axis with the pinion there is a toothed wheel which drives a pinion carrying upon its axes a fly, so that whenever the contact arm, E, moves, the fly revolves, and, as before explained, the resistance of this fly regulates the speed of the movement of the arm.

A notched arc, X, is provided upon the contact making arm, E, and a pawl lever, Y, upon the parts which are fixed to the lever handle. The pawl lever drops into the notch when the lever handle and the contact arm come together, and it thus aids in bringing the contact arm to rest in the proper position.

In the receiver, which is shown by fig. 4, N, N, N, are three electromagnets, each connected with a separate line wire (1, 2, 3) passing from the transmitter to the receiver, and all connected to the same return wire (3). O, O, O are the armatures of these electromagnets; they are pivotted at O^1, and their other or free ends have connecting rods, P, P, P, jointed to them. These connecting rods all embrace the same pin, Q^1, set eccentrically on the central axis, Q. This axis, Q, has a pinion upon it, and it drives another axis which carries a finger pointing upon a dial to words corresponding to the signals sent by the transmitter.

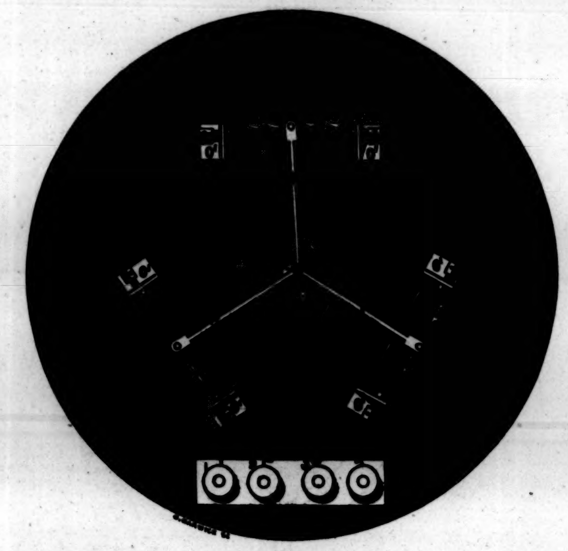

FIG. 4.

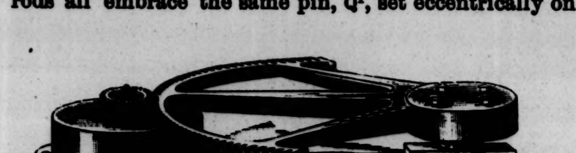

FIG. 5.

Fig. 5 shows a form of gearing employed for telegraphing the position of the rudder. The toothed arc is connected to the rudder, and gears into a transmitter somewhat similar in principle to that of the bridge telegraph; it is, however, so arranged that the contacts made are only momentary, no matter how slow the rudder may move or what position it may stop at; thus the running down of the battery from continued action is prevented. The receiving portion of the instrument (fig. 6) is similar to that of the bridge telegraph, except that the dials are divided up into degrees instead of orders.

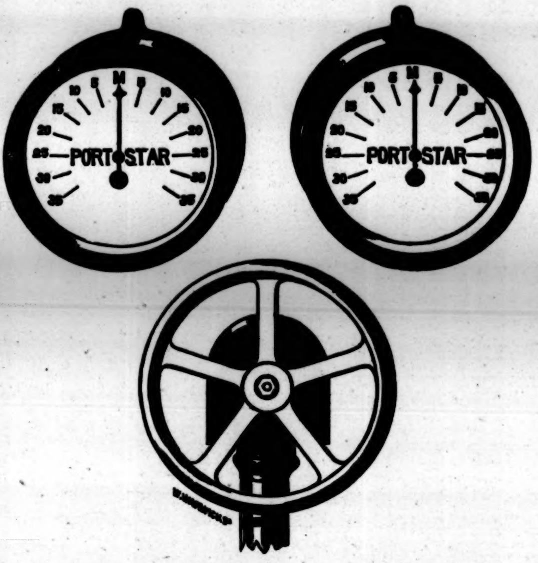

FIG. 6.

It will be observed that two dials are provided, placed near the steering wheel. On one dial the orders (number of degrees) are received from the bridge, and on the second dial the steersman who moves the steering wheel accordingly sees when he has moved the rudder through the corresponding required angle.

Messrs. Elliott Brothers, of St. Martin's Lane, are the sole manufacturers of the apparatus.

A DESIGN FOR A STANDARD OF ELECTRICAL RESISTANCE.

By J. A. FLEMING, M.A., D.Sc., Professor of Electrical Technology in University College, London.*

IN designing a standard of electrical resistance the two points to which attention is directed are the choice of the material in which the standard is embodied, and the form or disposition of the instrument.

Experience is yet far from complete as to the entire permanence of wires of alloys over prolonged periods of time when employed as standards of electrical resistance; but having regard to the inconveniences which attend the use of mercury in standards intended to be conveyed about, evidence, as far as we have it, points to the tolerable permanence of the platinum silver alloy (66 p.c. of silver + 32 p.c. of platinum) when drawn into wire, for use as the material substance of which the actual standard is made.

A definite length and gauge of standard wire has then to be so arranged that, whilst kept at a constant temperature, currents can be passed through it and the resistance between certain points ascertained.

The form which has hitherto been chiefly manufactured, and which is in most general use, is the form of standard which was designed by the Committee of the British Association on the original introduction of the B.A. unit. In this form of standard the actual coil is wound on a bobbin consisting of a tube of thin brass having ebonite cheeks. Attached to these cheeks are the two long bent copper rods which serve as the electrodes, held in position by a distance piece of ebonite. In order that the coil may be immersed in a medium of known temperature it is further enclosed in a thin shell of brass consisting of a double tube, and the whole shell filled up with paraffin wax or ozokerit. Some makers then place a thin lid of ebonite on the top of the shell.

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* Abstract of paper read before the Physical Society on November 10th, 1888.

Experience gained by a rather extensive use of standards of resistance of this form has indicated to the writer that this design can be, with some advantage, modified. The disadvantages of the present B.A. form of standard are as follows :—When in use the standards must be placed in water of a known temperature or in melting snow or ice. After a sufficiently prolonged time the temperature of this water can be taken, and the temperature of the water will be the temperature of the wire of the standard, assuming that equilibrium of temperature has been attained. If a current is now passed through the coil in order to take a measurement of its electrical resistance, the temperature of the wire is raised, and its resistance is altered.

Other things being equal, the best design of coil is that in which this electrically developed heat is got rid of by diffusion as quickly as possible. The embedding of a coil in a large mass of badly-conducting material like paraffin or ozokerit is, from this point of view, a great disadvantage.

Sufficient electrical insulation has to be provided; but this should be achieved without the use of more enveloping insulation than necessary.

The two chief objections to the B.A. form of standard are, however, these :—

1. It cannot be placed in water with the shell wholly under water or under ice without short-circuiting the electrodes, and, when used as intended, whilst the narrow or bottom portion of the coil is in the water, the upper and more massive portion is in the air, and therefore may be at a different temperature to the bottom portion. Hence arises a doubt as to the actual temperature of the coil of wire. It has to be borne in mind that the limitation of accuracy in such comparisons of standards of resistance is determined by the difficulty of ascertaining temperature, and not in the mere measurement of resistance. Uncertainty as to the actual temperature of the wire to the extent of one or two-tenths of a degree Centigrade renders nugatory elaborate arrangements for very accurate measurement of resistance.

2. The standards, as at present constructed, are liable to another defect. If the standard is being used in melting ice or snow, and therefore cooled to 0° Cent., deposition of dew will take place upon the upper surface, whether it is the ebonite lid or paraffin-wax surface, through which the copper rod electrodes protrude. The copper rods are originally lacquered or varnished, but when the lacquer wears off, any film of moisture so deposited will short-circuit the electrodes and reduce the observed resistance. In comparing standards in melting ice, either then the whole shell must be as far as possible placed under the melting ice, in which case stirring the liquid may splash water on to the surface of the paraffin, or else the shell has to be only partly immersed, in which case ambiguity exists as to the actual temperature of the coil of wire.

These and some other difficulties, such as that of keeping a rather deep vessel of melting ice at a constant temperature, have impressed on the writer the necessity for modifying the form of the standard, and one form which has proved itself to be very satisfactory in use is as follows :—The case or shell which contains the coil is in the form of a ring (see fig. 1). This ring consists of a pair of square sectioned circular troughs provided with flanges which can be screwed together so as to form a square sectioned, hollow, circular ring.

From this ring proceed upwards two brass tubes about 5 or 6 inches in length. Down these brass tubes pass the copper electrodes or rods, and these rods are insulated from the tubes at the top and bottom by ebonite insulators. The insulator at the bottom of the tube, where it enters the ring, is a simple collar, that at the top has the form of a funnel corrugated on its outer surface. The use of this funnel will be referred to presently. The actual resistance coil is a length of platinum silver wire three-fold silk covered. The silk-covered wire is first baked above 100° C. to dry it completely, and then immersed in melted ozokerit or paraffin.

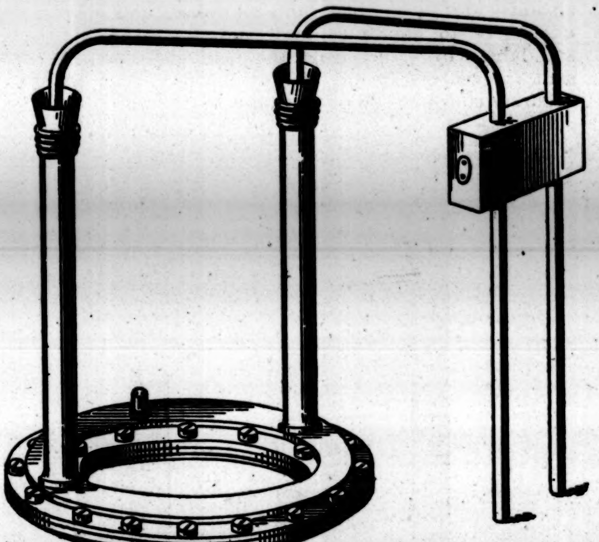

FIG. 1.

The so insulated wire is cut about the proper length and laid double or folded once upon itself and then rolled up on a wooden mandril so as to form a circular coil of diameter suitable to drop into the hollow of the brass ring. The wire being wound double, its coefficient of self-induction is rendered very small. This coil of wire is then wrapped over with white silk and again dipped in melted ozokerit. The ends of the wire are next soldered into nicks in the ends of the copper rods, they having been previously pushed a little way through the brass tubes for the purpose, and afterwards drawn back into proper positions. The coil is then packed into the circular groove, and, after adjusting the resistance to the proper value, the bottom half of the ring is placed over it. A thin washer of India-rubber is inserted between the flanges, and the whole screwed tightly together. The resistance coil is thus enclosed in a thin ring of metal, and can be placed wholly below the surface of water or ice. In order to test the tightness of the joints, a little test pipe is provided on the upper surface of the ring. By placing the ring coil below water and blowing into the test pipe, the good fitting of the joints can be assured. The aperture of this test pipe is afterwards closed by solder or a screw (see fig. 2).

Apart from the insulation of the coil itself it will be apparent that the insulation is limited by the amount of insulation resistance secured at the ebonite insulators at the top end of the brass tubes. Any leakage from the copper rod over these insulators to the brass tube destroys to that extent the insulation of the coil. The object of making these external insulators funnel shaped is to prevent surface creeping, due to condensation of moisture on them, by placing paraffin oil or insulating liquid in the funnel-shaped cavity. When this is done, even if dew should collect on the outer surface of the funnels the inner surface is kept dry by the paraffin oil placed in them, the action being the same as that in the well-known Johnson and Phillips fluid insulator.

The ring coils when in use are placed in rather shallow zinc troughs, which can be filled with water, and which are closed with a wooden lid. When so placed the whole of the actual coil or resistance part is down beneath the liquid at one level, where the temperature can be accurately ascertained. The insulators and point of emergence of the electrodes are away up above the level of the water, and well protected from any action which might permit of leakage over them. The large metallic mass of the ring assists in bringing the resistance coil quickly back to the temperature of the surrounding water, and the coil therefore "tests quickly." In all other respects these standards of resistance are as compact and portable, and not more expensive to construct than the old form of B. A. standard, whilst obviating the difficulties which present themselves in the use of the old form in very accurate comparisons of resistance.

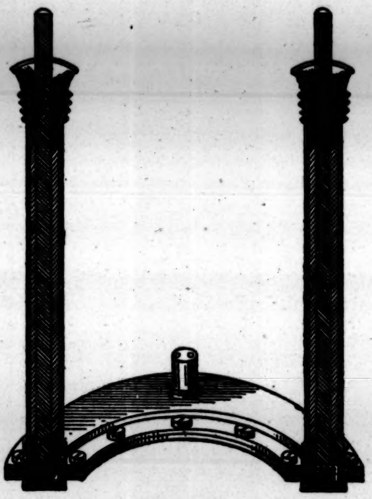

FIG. 2.

It is quite possible to have two or more coils of wire inside the same ring, each coil having its separate pair of electrodes. A useful coil of this form can be made up containing 1, 10, and 100 ohms, so that comparisons can be quickly made at the same temperature with these three multiples of the same unit of resistance.

The adjustment of the coils to a certain value presents no great difficulties. The wire is in the first instance cut a little longer than required, and its resistance nearly adjusted; when the two ends of the coil have been soldered to the lower ends of the copper rods, the resistance is again taken from the ends of the electrodes. This resistance should be a little greater than the final value required. The middle point of the wire or extreme loop is now stripped of its silk and the loop twisted up with the pliers, the resistance being carefully taken at intervals. When just a very little in excess of the value required the twisted coil is touched with solder, and having been bound over with insulating material the coil is completed. In the construction of standards it is obvious that it is not so important that the resistance should have an exact integer value at any temperature as that its value at some temperature and its coefficient of variation of temperature should be exactly known.

Telegraphic Communication in Greece.—It appears from the report issued by the director of the telegraph department in Athens that the telegraph system is being steadily developed in Greece, though, of course, not so rapidly as in many other countries. During the year 1883 there were sent 337,339 messages to the interior, and 47,940 to foreign countries, but in 1887 the figures had risen to 439,619 and 63,417 respectively, which showed an increase of about 25 per cent. in the five years. It is stated that the returns for 1888 will show a still further development.

NOTES.

Dublin and the Electric Light.—At a special meeting of the Dublin Corporation on Monday, Mr. J. L. Robinson moved: "That all necessary steps be taken to obtain a licence to authorise the Corporation to supply electricity for private purposes within the area of the City of Dublin." A resolution was passed some time ago authorising an application for a provisional order, the gas company having served the Corporation with notice that it was about to take such a step itself; the gas company, however, had not lodged the necessary plans by the proper day, and the Council had decided to abandon the provisional order and move for a licence, which would be much less expensive. The Town Clerk of Waterford, it was incidentally mentioned, had stated that in that city they had been using electric light and oil instead of gas and had found the result to be far more satisfactory and much cheaper. The motion was carried by a majority of 37 to 1.

Ball Room Lighting.—An invitation ball was given at Stowmarket last week and was a great success, due in part to the electric light, fitted up for the occasion by Mr. Napier Prentice. Four lamps of 300 candle-power each, and one lamp of 500 candle-power, gave a pleasant and even light, showing off the decorations to great advantage. The inconvenience generally caused on such occasions by the heat of the gas was, of course, entirely avoided, the ballroom remaining cool and pleasant throughout the night, so much so that dancing was kept up with vigour until after 5 a.m. The portable engine used for driving the dynamo was kindly lent by Messrs. Woods & Co., of Stowmarket.

Liverpool and the Electric Light.—The Watch Committee has resolved, after considering a report of the city engineer on an application of the Liverpool Electric Supply Company for the consent of the Corporation to their applying for a provisional order, that the Town Clerk reply that, having regard to the short time which has elapsed since the grant of the licence, the committee has not had sufficient opportunity of observing the working of the system to enable it to adequately consider the application, and therefore cannot recommend the Council, as the local authority under the Electric Lighting Acts, 1882 and 1888, to consent to the company making an application for a provisional order. The Health Committee has approved of a report of the city engineer on plans submitted by the above company showing the positions in which it is proposed to lay mains in the streets.

Electric Light in Halifax.—The Schmidt-Douglas Company has recently lit a portion of the works of Messrs. John Carter & Co., worsted coating manufacturers, New Bond Street, Halifax. A series dynamo, worked from the shafting, supplies six arc lights, and the special advantage of the system adopted is that each lamp can be used separately at will.

Electric Lighting in London.—At the last meeting of the Metropolitan Board of Works, the Parliamentary Committee reported that they had considered the electric lighting provisional orders, and under the provisions of the Acts 1882 and 1888 the Board was bound to send in its objections to the Board of Trade on or before that day week. They recommended that the solicitor be instructed to communicate with the Board of Trade, and requested further time to submit any necessary observations. The report was adopted.

The vestries of St. Martin's-in-the-Fields and St. George the Martyr have resolved to dissent from the applications of the House-to-House and London Electric Supply Companies for provisional orders.

Hove and the Electric Light.—The Hove Commissioners have decided to withhold their consent to the provisional order for electric lighting applied for by the Brighton and Hove Electric Light Company.

Kensington Electric Lighting.—We understand that at the meeting of the Vestry of St. Mary Abbott's, Kensington, on Wednesday, the report of the special committee appointed to consider matters relating to electric lighting was brought up and passed. The effect of this is to allot a portion of the parish to each of the following six companies. The area of the parish north of Kensington Road is divided between the London Electric Supply Corporation, the Metropolitan Electric Supply Company, and the Notting Hill Electric Light Company; and the area of the parish south of the Kensington Road is divided between the Kensington and Knightsbridge Electric Lighting Company, the Chelsea Electricity Supply Company, and the House-to-House Electric Supply Company.

Telephone Statistics in Kent.—During the last nine months of last year the number of telephone messages transmitted between Dover and Folkestone over the South of England Telephone Company's wire was 54,165. It is stated that in consequence of the great increase in the number of weekly calls another wire will have to be run between the two towns before the commencement of the summer. The returns for each month are as follow:—April, 5,297 calls; May, 5,901; June, 4,475; July, 4,963; August, 7,428; September, 5,655; October, 7,092; November, 7,801; December, 5,553. During the latter month the office was closed several days for the Christmas holidays.

Telephonic Messages.—A correspondent suggests, as "an appropriate and convenient name for a telephonic conversation," the word "Telecon."

The Institution of Electrical Engineers.—A "Provincial Member" writes: "Surely, the Council of the above Institution has committed a blunder by prohibiting the Press reporting papers, &c. I am afraid this must have a serious effect upon the membership. We in the provinces have always been heavily handicapped, and now we shall know nothing of the Institute's proceedings until months after. Surely the fact of our being debarred from the use of the library, unless we visit it (a benefit which is also given to the general public), might have caused the Council to consider carefully before applying the clôture to the Press. We cannot deny there has been a vast amount of gratuitous advertising done at our meetings, but it is well known that the greatest sinners in this respect have at one time or other been members of Council. Why should there be any difficulty in so arranging matters that our worthy secretary could, with a few strokes of the pen, make short work of such advertisements?" [We would remind our correspondent that the secretary does not edit the papers sent in for reading.—EDS. ELEC. REV.]

Electrolytic Inner Cells.—One of our contemporaries, quoting from the New York *Electrical World*, describes a new form of battery devised by Messrs. Roberts and Brevoort, the porous partition separating the two liquids having electrolytic properties. Thus if the battery be on open or closed circuit, the liquid, as such, on one side of the diaphragm, would not intermingle with that on the other side, or only to a limited extent. In a recent form of cell, the inventors impregnate the porous partition with gelatinous silicate of soda. It may not be generally known that an invention which appears to be precisely similar to the above, was patented here on the 20th July, 1887, by Messrs. Mayer and Liepmann, and we believe that steps have been taken to oppose the granting of an English patent to Messrs. Roberts and Brevoort. It is possible that we may be in a position to give further information on this subject in a future issue.

Electric Launch for the Sultan.—A launch with a swan's-neck prow, to be driven by electricity, is being built at Richmond for the Sultan. It is to be delivered at Constantinople in April.

Gilbert's Shackle Ball.—In the *Telephone* of 15th ult., we observe some criticism on this invention by Mr. A. R. Bennett, to the effect that the insulator is useless in wet, and not wanted in dry weather. We think this rather a bold and unguarded assertion, because small as the break is between the wire loops, there must, unquestionably, be additional insulation, and, in our opinion, to no small degree.

Lithanode.—The consulting electrician to the Mining and General Electric Lamp Company, Limited, Mr. D. G. Fitzgerald, has forwarded to us samples of "Lithanode." Hitherto, by the policy of other companies, who previously owned the patents, lithanode has been most jealously guarded from the public gaze, and no samples have been issued for experimental purposes to the public. The directors, however, have decided to issue such samples to anyone who does not mind the trouble of applying for the same, enclosing a stamped addressed label. The plates sent to us are suitable for cutting up into smaller ones by the aid of a fretsaw, and one ounce of material will give one ampère-hour of current, and if combined with zinc as the cathode, 2·375 volts, or with spongy lead, 2 volts; in ordinary dilute sulphuric acid sp. gr., 1·170. A small sample plate shows the best means of making connection, but Bunsen battery clamps with platinum foil will answer, also carbon blocks or rods bound upon the plate.

Recent Interruptions and Repairs to Landlines and Submarine Cables:—

	Interrupted.		Repaired.
Land line, Teheran-Bushire (Indo-European)	9th Jan., 1889	...	10th Jan., 1889.
" Saigon-Bangkok	12th Jan., 1889	...	15th Jan., 1889.
	19th Jan., 1889	...	24th Jan., 1889.
" Transandine ...	19th Jan., 1889	...	26th Jan., 1889.
Cable, Trinidad-Demerara	13th Dec., 1888	...	27th Dec., 1888.
" Punta Rassa-Key West	5th Jan., 1889	...	18th Jan., 1889.
" Jamaica-Colon ...	22nd Dec. 1888	...	19th Jan., 1889.
" St. Vincent--Barbadoes	19th Jan., 1889	...	26th Jan., 1889.

New Electrical Periodical.—We have received the first number of the *Anales de la Electridad*, a technical fortnightly, dating from Barcelona, the Spanish commercial capital. The modestly written programme which Dr. Suarey Saavedra lays before his readers commands our esteem. While wishing our new contemporary success, we cannot but fear that the venture is in advance of the immediate requirements of Spain and the Hispano-American States. The style of journal best suited to the case would appear to us to be a publication somewhat similar to our lately born colleague, *Industries*, in which the extent of field comprised assures a regular supply of interesting matter, even when strictly electrical subjects fail. Spain already possesses the *Revista de Telégrafos*, a semi-official periodical, and, at least, one other electrical journal, which we think meet the demands of Spanish specialists. Any further information these readers may require can easily be culled from the French technical press, of whose language every scientific Spaniard possesses a considerable knowledge. We would therefore recommend Dr. Suarey Saavedra to modify his programme, and to model his journalistic matter after the style of *Industries*. Whether he takes our advice or not, we cordially wish him that success which we always desire for those whose publications disseminate electrical knowledge.

Soirée.—On Friday, the 25th ult., the Manchester staff of the Lancashire and Cheshire Telephonic Exchange Company held their fifth annual soirée at the Manchester Athenæum. There was a large attendance of officials and friends and a most enjoyable evening was passed. As in each previous year, Mr. Joseph Poole (chief electrician to the company) made an able and popular "M.C.," and his efforts were well supported by the stewards—Messrs. R. F. Beer, T. J. Clark, W. G. Heys, A. Hodgkinson and E. Whitworth.

Taunton Electric Lighting.—The following facts with regard to the lighting at Taunton may be of interest. This was the first central station in England on the Thomson-Houston system, and the plant was installed by Laing, Wharton and Down, to the order of Mr. Massingham, who believed that a profit could be made by supplying the electric light to his fellow citizens. At first he could get no support at all, and had to find the money himself; besides this, when the plant was started on May 1st, 1886, with a capacity of 30 arc lamps, not one was being paid for. By September, however, all the lamps were taken up on a paying basis, and, a town contract being shortly after awarded, the whole plant was duplicated, making a capacity of 60 arcs. Incandescents were also added, and by the beginning of the next year it was recognised by the Taunton people that the central station was so assured a success that it was bought up by a local company, formed for the purpose. The plant was further developed to cope with the growing demand, and the business was so prosperous that at the end of the first year's working it was possible to pay a 5 per cent. dividend. The station has now reached the end of its second year of existence, and the plant consists of four 30-light arc machines and two incandescent machines, with accumulators, the station being loaded up to its utmost capacity. The directors' report, just out, proposes a dividend of 6 per cent. free of income tax. The demand for the lights is still increasing, and it is under consideration to build a large new central station with ample room to extend hereafter, the plant being immediately largely increased.

After Dinner Speeches.—The post prandial orators at the inauguration banquet of the Kensington Central Station were very eloquent, but their speeches, like the sweet prattle of young lovers, were full of soft nothings. How everybody must long for the time when we shall be told a straight-forward history of deeds successfully accomplished and of mighty undertakings firmly established.

Electric Traction Coming.—We hope that some of our enterprising firms are tendering for the equipment and working of the Morecambe Tramways Company by electricity. Surely this would be a good opening for the Elieson Electric Company, whose locomotives are, unfortunately, at the present moment taking an enforced rest? At all events, there is more good to be accomplished by throwing some energy into a matter like this than by splitting up the board of directors into opposing factions. The experience gained by this company on the Manor Park line should be sufficiently valuable to render it a formidable opponent in the competition for the Morecambe contract, and now is the time to be up and doing, instead of wasting time and money in useless recriminations concerning the past.

Electric Traction on the Underground. — The directors of the Metropolitan Railway express regret in their report just issued that the Electric Traction Company has not been able to complete its arrangements for the experimental working by an electric locomotive on a section of the railway. Lord Bury, the chairman of the Electric Traction Company, writes to state "that the difficulties, which principally concerned the working of the vacuum brake without the use of steam, though intractable for a considerable time, have now been overcome. The whole matter is in active progress, and has made considerable advance since the last report. The Electric Traction Company wish it to be explained that an erroneous belief appears to be entertained that they propose to suggest traction by means of accumulators for ultimate use on the Metropolitan line. This is not the case. The use of accumulators is for a temporary service only, and is rendered necessary by circumstances connected with the traffic, which will disappear when electric traction is adopted on the underground railway."

The Schanschieff Battery.—We read in the *South Australian Register* that "the Schanschieff electric light" was placed in the saloon carriage for His Excellency Sir William Robinson on a recent trip to Melbourne, and was a complete success. The light was steady and good throughout the whole night and proved in every way satisfactory.

Death of the Austrian Crown Prince.—The death of the Austrian Crown Prince Rudolph deprives the scientific world of one of its most ardent admirers and supporters. Many of our readers will recollect the Vienna Electrical Exhibition of 1883, which was largely supported by His Imperial Highness, who took the deepest interest in its success. He was not only a frequent visitor, but he took infinite pains in informing himself of every detail in connection with electrical progress. He was thoroughly popular with all classes of his subjects, and a strong feeling of friendship and mutual regard existed between him and the Prince of Wales. Says the *Daily Telegraph*:—"They thoroughly understood and appreciated each other, and, had both of them lived, there can be no doubt that their friendship would have had a marked influence on the intercourse of England and Austria. The Prince of Wales was touched at all the delicate attentions shown him by the Crown Prince during his last visit to Vienna, and they spent the whole time together." During the Electrical Exhibition, the Crown Prince took trips on the Danube in the electric launch, with which his countryman, Mr. Reckenzaun, was connected. We deeply regret the great loss which the scientific world has sustained through the death of this excellent man and prince.

Bell's Asbestos Company, Limited.—A very successful first ordinary general meeting of this company was held at Cannon Street Hotel, on Wednesday. Mr. John Bell was able to announce highly satisfactory returns upon every head, and to propose the distribution of a dividend of 22½ per cent. He even gave promise of a still larger profit upon the transactions of the present year, and made the extraordinary statement, as showing the widespread nature of the dealings of the company, that they could hear with calmness of the failure of a thousand of their customers. Their revenue was made up of trifling sums, paid by many thousands of people."

The Electro-Harmonic Society.—The concert of last Friday proved to be one of the most successful yet given by this society, and nothing could more forcibly bring to mind the benefits of such meetings than the remark which Mr. Parsoné, so well-known abroad in connection with the India-Rubber and Gutta-Percha Company, and with cable matters generally, made to one of us on the evening in question. "Here," said Mr. Parsoné, "I have found in a short time many acquaintances that I have not seen for years, and if I had tried to seek them out individually it would have taken days." It is very pleasant for electrical men, whose work is no sinecure in these days of pioneering, to be able, once in a while, to throw dull care to the winds, and spend several hours in social intercourse and pure enjoyment, and we were pleased to notice amongst the large gathering several well-known country members. Prof. George Forbes made an admirable chairman, his pleasant and sonorous voice being clearly heard in every part of the room.

An Electric Brake.—The Widdifield and Bowman electric car brake was subjected to a series of tests on January 10th, a train of 15 freight cars being used for the trial, which took place upon the Lehigh Valley railroad, between Metuchen and Easton. In all the trials, which included emergency and service stops, cutting off portions of the train, &c., the mechanism worked perfectly. Its cost was stated to be but a small fraction of that of an air brake equipment.

The Edison Chemical Meter.—That portion of Mr. Jenks's paper which we publish this week is interesting as showing the value of the criticisms of some of our contemporaries.

The Water Primary Battery.—It is said that Mons. D'Humy has placed his water battery in America for the sum of £120,000, one-third of this being in hard cash. If this is correct, it may be looked upon in the light of a *quid pro quo* for the electrically refined sugar business, to which we were indebted to American smartness. This information, however, appears too good to be true, although the gentleman in question is said to be living in clover not a hundred miles away from Gray's Inn Road.

Transmitting Power by Alternating Currents.—We are indebted to Mr. A. du Bois Reymond for preparing and sending to us an English version of the paper which he read before the Electrotechnical Society of Berlin in December last. We greatly appreciate this gentleman's courtesy, and we feel sure our readers will find much in the article to interest them.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Maxim-Weston Electric Company, Limited.—An agreement, dated 21st inst., provides for the transfer of the business and goodwill of the old company to the new company in consideration of the issue to the liquidators of the old company of 312,000 shares in the new company, with 2s. per share credited as paid up. Registered office, 2, Metal Exchange Buildings.

Equitable Telephone Association, Limited.—At an extraordinary meeting of the shareholders in this company, held at 75, Queen Victoria Street, on the 19th inst., it was resolved to wind up voluntarily, and to appoint Mr. Charles Lee Nichols, of 1, Queen Victoria Street, chartered accountant, as liquidator at a fee of 50 guineas, it having being proved that the company, by reason of its liabilities, cannot continue its business. The last return of the company was filed on the 16th April last, and this document stated the nominal capital to be £6,000 in £5 shares, the whole being taken up. £3,000 was considered as paid upon 600 shares, and £2,990 on a further 600, the unpaid capital being £10.

Brighton Electric Light Company, Limited.—The Board of Trade (Railway Department) has, by a letter dated 23rd inst., signified its approval of the name of this company being changed to the "Brighton and Hove Electric Light Company, Limited," and on the 24th inst. the alteration was made upon the Register of Joint Stock Companies.

W. T. Henley's Electric Light and Power Company, Limited.—The annual return of this company, made up to the 11th inst., was filed on the 19th inst. The nominal capital is £100,000 in £1 shares. 6,918 shares have been taken up, and the full amount has been called thereon. The calls paid amount to £6,911, and unpaid to £7. £41 10s. 11d. has been paid in respect of 101 shares forfeited.

Society of Telegraph-Engineers and Electricians.—At a special general meeting of the members of this society, held at 4, The Sanctuary, Westminster, on the 20th ult., and at a subsequent meeting held at the Institution of Civil Engineers, 25, Great George Street, on the 10th inst., the following special resolutions were duly passed and confirmed, and were registered 22nd January, viz. :—"That the regulations of The Society of Telegraph-Engineers and Electricians, as contained in their memorandum and articles of association" be altered by substituting the name "The Institution of Electrical Engineers," for "The Society of Telegraph-Engineers and Electricians," and also by substituting the word "Institution" for the word "Society" whenever the same respectively occur in the regulations.

LEGAL.

In re Gaulard and Gibbs's Patent.—(Before Lords Justices Cotton, Lindley, and Lopes.)—The arguments in the appeal in this case terminated on Friday morning last week, when their Lordships stated that they would consider their judgment, but not for so long a period, they thought, as the arguments had taken up. Their Lordships added that it seemed to them a great waste of public time that such cases as the present should interrupt the ordinary business of the Court for nearly a fortnight. In this case the arguments appeared to have been considerably longer than they need have been. If four days only had been occupied it would have been ample time. It seemed imperative that some new system should be introduced. Instead of reading at full length the whole of the evidence adduced in the Court below it might, in many instances, be sufficient to state only to the Court of Appeal the effect of it.

CITY NOTES, REPORTS, MEETINGS, &c.

Eastern Telegraph Company, Limited.

THE thirty-third half-yearly ordinary general meeting of this company was held at Winchester House, E.C., on Thursday, the 24th ult., Sir John Pender, K.C.M.G., presiding.

Mr. Geo. Draper, the secretary, having read the notice convening the meeting, and the report of the directors, which appeared in the REVIEW for January 18th, having been taken as read,

The Chairman said he should, as usual, give some fuller details than were given in the report, although the report was very full indeed. The revenue for the six months ended September, 1888, amounted to £310,104, as against £291,265 in the corresponding half-year of 1887, showing an increase of £18,839. The chief item of increase was from their holding of shares in the Eastern and South African Telegraph Company, the dividend on which was at the rate of 12 per cent. per annum as against 8 per cent. per annum in the corresponding period of 1887, showing an increase of £7,800. The return for the half-year from their investment in the Black Sea Telegraph Company was increased by £1,393, and their direct Spanish shares had yielded an additional £307. Interest gave them an extra £600, transfer fees £13, and the general traffic, chiefly South African and South American, £10,531. This, altogether, made a total of £20,644. But they had ceased to bring into their revenue accounts the dividend on the Direct Spanish Company's debentures, which were now considered as an investment for the reserve fund, so that they must deduct £1,805, leaving the total increase at £18,839. The total working expenses for the half-year amounted to £83,332, against £79,936, or an increase of £3,396. The details of increase and decrease were as follows:—General expenses in London, £7,845, against £8,012, or a decrease of £167; working expenses at stations, £59,962, against £56,386, being an increase of £3,576. This was principally caused by the number of the foreign staff having been increased to work the triplicate cable from Porthcurnow to Malta, and the extension to Zante, and also the duplexing of that cable. They had also opened a new station at Cadiz, having put that place in telegraphic communication with Villa Real and Gibraltar. The laying of the new cable from Porthcurnow to Malta and Zante, besides giving them greater security and rapidity of working, had diverted to their system a large part of the Greek and Turkish traffic, which formerly went *viâ* the Continent. These explanations also accounted in a great measure for the increase in travelling expenses, rent, stationery, and maintenance of instruments. A greater number of messages had been carried during the past half year than in the corresponding half of the previous year, and the work to be performed by their staff increased year by year. £1,000 of the total increase in the working expenses was explained by their having carried £5,000 to reserve for maintenance of ships, against £4,000 last half year. The repairs to cables amounted to £43,075, against £34,102, or an increase of £8,973. This was always an uncertain item in their accounts. Their ships had been busily employed in maintaining their system in a state of efficiency. The increase under this head was in the value of the new cable laid in, the total length being 130 miles, against 38 miles in the corresponding half of 1887. They would find on reference to the reserve fund that they had applied over £13,000 in reduction of capital expenditure, or, in other words, although they had spent more than £13,000 in improving and extending their system, the capital expenditure remained at practically the same figure as last time. The six per cent. debentures of the Direct Spanish Company had been transferred to the reserve fund investments, which stood at £315,494, and their total reserves, after deductions, at £355,676. They paid the usual interim dividend at the rate of 5 per cent. per annum, and after providing for interest on debentures, debenture stock, and preference shares, they were able to carry £36,616 forward to the next account, against £29,397, or £7,219 more than in the corresponding period of 1887. He gave them these details because he thought it desirable that they should follow as closely as possible the practical operation of the company. The statement which he made six months ago was so full of details and so complete a history of the company from its beginning that little was left for him to say that day, excepting to state that all that he put before them at the last meeting had been carried out; all the shares had been allotted and fully taken up. He believed that by the time he had the pleasure of meeting them again six months hence they would have completed their West Coast of Africa cable, and that would not be completed one hour too soon. The enormous traffic going on just now to the Cape and the Transvaal, caused by the gold speculations, of course brought a great deal of grist to their mill, and any interruption to the present cable would be very disastrous, and would be felt to such a degree in London that he feared to contemplate what the result would be. Their system was working thoroughly well. They had a great deal of work to do. A very large sum was mentioned in the report for extensions and repairs, and he thought it would be worth while to read to them what those repairs and extensions were. Having read the list, the Chairman proceeded to say that they held a public property and were maintaining it for the public benefit—a grand system of communication for the world; and this was done at a considerable expense and by a considerable amount of labour. The public did not know of the work which their steamers were almost perpetually engaged in, and it was all the more interesting in that it was performed silently. Cables would get old as well as men, and they were endeavouring to renew out of income rather than by increasing their capital. While their cable ships were at Suakin they gave every possible assistance to the Egyptian Government, and they had the satisfaction of knowing that their services were greatly appreciated. He hoped that when they came to make a bargain with the Government the latter would bear those services in mind. Sir John then moved the adoption of the report and accounts.

The Marquis of Tweeddale seconded the motion.

Mr. Goodstall asked how far from Aden and how far from Bombay the No. 1 cable had broken.

The Chairman said that it was at that moment undergoing repair. He had expected to be able to report the repair that day.

Mr. Goodstall: But how far?

The Chairman: 700 miles from Aden.

Mr. Goodstall: Has it been repaired there before?

The Chairman: Not in that particular spot. But you know that as well as I do. Continuing, Sir John said the gentleman who had just spoken had been a captain in the company's service, and all he (the chairman) would say was that he left the service for the service's good. He had an object in asking those questions.

Mr. Goodstall: Yes, I know, but the shareholders don't. And it is in order that they may know that I put these questions. There were other questions which he wished to ask. They had in the accounts a large sum for advertising; would they kindly tell him where they advertised in London? He had never seen any advertisement except in the *Electrician*, and if they paid £221 for that, they paid decidedly too much. For the last half year the amount was £540. It was not right for the chairman and managing director to have shares in a paper which was the only paper in which the company advertised. Why did they not advertise in the ELECTRICAL REVIEW, or the *Electrical Engineer?* The circulation of the *Electrician* was probably only about 2,000 a week. Or why did they not advertise in the *Times?* Referring to the trips taken by the chairman and other directors in the company's ships, he said he thought they should bear the expense of those trips themselves.

Mr. J. F. Waller said he had never seen anything so irregular or so disorderly as the proceedings of the previous speaker. He had appealed to the shareholders, but he (Mr. Waller) failed to hear one sympathetic voice in response; but he was glad to hear, by the acclamation then greeting his own words, that his views, and not those of Mr. Goodstall predominated amongst the shareholders. He hoped Sir John Pender would not condescend to any further explanation of the matter.

The Chairman said he would have treated the remarks alluded to with contempt, but there were one or two charges made which it would be as well for him to answer. First, as to the *Electrician*. He wanted those connected with these companies to know the history of that paper. The *Electrician* was established for the purpose of getting the best scientific opinion upon questions relating to their cables. Sir James Anderson and one or two gentlemen interested in telegraphy established that paper, and they had not taken one shilling of profit out of it. They established it entirely for the benefit of that system with which they were so closely connected. It was an enormous benefit to their young men all over the world to get the latest scientific knowledge, and that paper was circulated all over their telegraph system. He thought that was a sufficient answer to the remarks of Mr. Goodstall. It had been no matter of profit, but a great matter of interest that a thorough knowledge of telegraphic science should be disseminated over their systems. Another question which had been raised was the trips taken by himself in the company's ships. He did occasionally in the autumn and sometimes in the spring, when there was any matter of negotiation proceeding, himself go to the place necessary, because he always found that those negotiations were much more successful when conducted personally than when carried out by correspondence. The result had been enormous *kudos* to the company all over Europe. He could say with perfect confidence that the company would not have occupied the position it did had it not been for their frequently coming into contact with the Great Powers of Europe. He had availed himself of the ships from time to time, and occasionally took a friend with him; and he always took a man who could be of great use to them in appreciating the vast importance and value of their system. Those excursions had added honour and position to the company, and they intended to continue them as long as they were able to do so. It was no great benefit to him personally; on the contrary, it often entailed some amount of sacrifice. There was a very important business pending in a certain part of the world with regard to the renewal of concessions, and he was going there, because he thought he should thus secure their renewal on satisfactory terms.

The resolution was then put and carried unanimously.

Lord Sackville A. Cecil and Sir A. J. Leppoc Cappell were re-elected directors, and the meeting terminated with a vote of thanks to the chairman.

Anglo-American Telegraph Company, Limited.

THE report of the directors states that the total receipts from the 1st July to the 31st December, 1888, including the estimated balance of £390 12s. 8d. brought forward from the last account, are estimated at £131,186 6s. 11d. This amount is, however, subject to revision upon settlement of the accounts with the Paris New York Telegraph Company. The traffic receips show an increase of £35,352, as compared with the corrcsponding period of last year.

The total expenses of the half year, including repair of cables, &c., as shown by the revenue account, amount to £51,110 13s. 11d.

Interim dividends of 7s. 6d. per cent. on the ordinary stock, and 15s. per cent. on the preferred stock, were paid on the 1st November last, absorbing £26,250, leaving an estimated balance of £53,825 13s., out of which the directors recommend the proprietors to declare final dividends of 15s. per cent. on the ordinary stock, and £1 10s. per cent. on the preferred stock, amounting to £52,500, making a total distribution for the year ended the 31st December, 1888, of £1 12s. 6d. per cent. on the ordinary stock, and £3 5s. per cent. on the preferred stock, leaving an estimated balance of £1,325 13s. to be carried forward to the next account.

The company's repairing ss. *Minia* has been engaged during the past half year in the repairs of the Brest St.-Pierre cable, the St. Pierre-Duxbury cable, the Southern Placentia-Sydney cable, the tricore Placentia-St. Pierre-Sydney cable, the Prince Edward Island cable, and the shore end of the 1873 cable at Heart's Content.

The Brest-St. Pierre cable was broken in four places, two of the faults were in deep water, and two in shallow water.

The total cost of the repairs to the Brest-St. Pierre cable amounts to £21,924 15s. 3d., all of which has been charged to the renewal fund, a large quantity of cable having been expended in the renewal of the line.

The interruptions to which the St. Pierre-Duxbury cable has constantly been subjected by the anchors of fishing vessels have decided the directors to divert and renew a considerable length of the line during the course of the approaching season. The cost of this work will also be charged to renewal fund.

The company's system of cables and land lines is in good working order, with the exception of the North Placentia-Sydney cable and Island Cove cable, both broken within the last few weeks.

The litigation between the Anglo-American Telegraph Company and the Paris and New York Telegraph Company is still pending, the points referred by the Paris Court of Appeal to the Conseil de Prefecture de la Seine for interpretation, not having yet been heard.

A Memorandum of Agreement was entered into on the 30th July, 1888, between the Anglo-American Telegraph Company, Limited, the Direct United States Cable Company, Limited, the Western Union Telegraph Company, La Compagnie Française du Télégraphe de Paris à New York, the Commercial Cable Company, and the Postal Telegraph Cable Company, by which the tariff for messages between Europe and New York and Canada was increased from 6d. to 1s. per word, and to 5d. per word for Press messages. The new tariff came into force on the 1st September last, and is to continue for one year certain, thirty days' notice by either of the parties being necessary to determine the same.

It is not possible to say, after so short an experience, whether the 1s. rate will ultimately become a financial success; but so far the results may be considered as fairly satisfactory.

The first four months of the 1s. rate, as compared with the last four months of the 6d. rate, show an increase of 111 per cent. in the revenue, and a decrease only of 11 per cent. in the volume of traffic.

As compared with the corresponding four months in 1887, an increase of 77 per cent. is shown in the revenue, and a decrease of 26 per cent. in the volume of traffic carried.

The differences between the several periods compared are largely due to the normal variation of traffic during the months under consideration, and to the proportionate alterations of percentage in the amounts paid out to connecting companies, under the 6d. and 1s. rates respectively.

Australasian Electric Light and Power and Storage Company, Limited.

THE directors of this company have just issued two circulars to the shareholders respecting schemes which have been under consideration for, in the first place, raising fresh capital, and secondly, for a reconstruction of the company. The nature of these schemes may be learnt from the following paragraphs taken from the circulars. After alluding to the expressions of opinion of the shareholders as to the desirability of raising further capital, and stating that a number of local financiers in Melbourne have intimated their willingness to join hands with this company, the affiliated Melbourne Company, and Messrs. Ganz & Co. (who have been in competition with the Melbourne Company), in forming a new company to undertake electric lighting in Melbourne on a large scale, and to start similar efforts in other centres, the first circular proceeds:—

"It is proposed that the first issue of capital of this new company should be £140,000; that of this sum, £40,000 in shares should be paid to our Melbourne affiliated company for its central station, which is already a paying concern, and for its manufacturing and general business; and that the remaining £100,000 shall be devoted to increasing that station by 20,000 lights, and to working capital for developing one or two definite schemes now in hand in other places. It has also been proposed that the new company should acquire the rights for Australia of our company, paying us a lump sum in shares; but the directors have made a counter proposal, which they have reason to believe will be accepted, not to take shares, but to receive one half the surplus profits after a fixed dividend has been attained. Certain orders are to be given to Messrs. Ganz for their incandescent plant, and, in consideration thereof, they will give the new company the control of all their patents and business in Australia, so long as a minimum of £15,000 worth of plant per annum is ordered from them.

"The net revenue to be derived from the central station when the new plant is in full work is estimated at £25,500 per annum, and our general manager has satisfied himself with regard to this estimate.

"Assuming that the scheme of reconstruction of our capital, which is recommended in a second circular herewith, be adopted and carried out, reducing the existing capital and raising a preference capital of £30,000, and that this company would then subscribe £30,000 of the £100,000 fresh capital to be raised for the new Melbourne company, the following would be the result to our company:—Estimated net revenue of the new Melbourne company, £25,500. Of this our company would receive, as ordinary shareholders, about £5,600, plus one-half of surplus after 7 per cent. has been paid, £7,850; total, £13,450. Upon this sum the £30,000, now proposed to be raised, would rank as a first dividend charge of 7 per cent., viz., £2,100, leaving an available surplus of £11,350 for further dividend on the £110,000 of preference and ordinary shares, and for administrative expenses and reserve or depreciation funds. A dividend, therefore, of 5 or 6 per cent. upon the ordinary stock, and of 12 or 13 per cent. on the preference stock of the reconstructed company may, in the opinion of the board, be reasonably expected. Of course the future development of the business would tend very materially to increase the results. . . . As the fresh capital now proposed to be raised would immediately make our investment in the affiliated Melbourne company of great value, and would likewise make our patent an income-earning asset, it is considered equitable to give to this new capital both a preference in capital and in dividend. It is proposed to make this latter 7 per cent. cumulative."

So much for the Australian scheme. In a second circular the directors say that, in view of the very important matters treated of in the other, they consider that the time has arrived when the capital of the company may with practical benefit be reconstructed. Then occurs the following paragraph:—"As the accounts of the company stand at present, there is a loss to debit of profit and loss account of £40,507, and, according to the legal decisions in similar cases, it would be impossible for the directors to declare any dividend until this loss has been made good, or written off the capital. There is also standing in the books a very heavy sum as cost of patents, against which nothing has as yet been written off by way of depreciation. In view, therefore, of the large income which it may now be hoped the company will enjoy, it is necessary, or at least highly desirable, to have the whole of the loss, and a large portion of the patents account, written off."

The existing shares of the company are divided into no less than five different classes, this peculiar state of affairs resulting from an amalgamation with the Australasian Edison Company. The directors think these should be consolidated into two classes at the most, and, in order to secure this end, they suggest the reduction of the £202,386 of existing capital to £80,000, all of equal denomination, the exchange of existing shares for new shares in given proportions, and the raising of £30,000 new capital in preference shares, bearing a 7 per cent. cumulative dividend.

This is the scheme of reconstruction, and we advise shareholders to look closely into it before giving it their assent. In the first place they should demand more recent information as to the exact financial position of the company than they have yet had. The paragraph quoted above sets forth that "as the accounts stand at present" there is a loss on the profit and loss account of £40,507; on reference to the balance-sheet for the twelve months ended December 31st, 1887, the last issued, we observe that that is the exact sum there shown to debit of profit and loss account. Of course in the case of a company whose business is at the Antipodes some considerable time must elapse before the shareholders can receive an exact statement of the accounts at the end of the year; but surely, having it in mind to submit some such suggestions as those now before the shareholders, the directors might have taken steps for the presentation of an interim balance-sheet, showing the position at Michaelmas, or even at Midsummer. The position cannot possibly be the same now as it was twelve months ago. Indeed, we believe one of the assets, computed in the balance-sheet for 1887 to be worth £18,000, has now ceased to exist; and if that is so the shareholders are entitled to know what sum its realisation added to the coffers of the company. We allude to the shares in the Australian Electric Company, which company was wound up some months ago.

The directors speak confidently of the central station in Melbourne. What is its extent? Are there 1,000 lights running from it? The sum of £40,000 is to be handed over to the Melbourne company for this central station, its manufactory and general business; £100,000 is then to be devoted to the extension of the station, the acquirement of the Australasian company's rights for Australia, &c. We would like to know at what figure the Australasian Company values its patents. They ask for half the surplus profits after a fixed dividend has been paid, but that gives little or no information upon the point. The patents originally possessed by the company were, we believe, those for compound-winding—now in by no means too secure a position; the Brush arc lamp, which has expired; and the Edison incandescent lamp, practically lost as a result of recent litigation; the Cheesbrough patent, the validity of which the Edison company here has managed to maintain, has never been registered in Australia—by no means a valuable set of patents, one would think. Then the formation of the new company will not, as a casual perusal of the circulars might lead one to infer, put an end to competition. The Electric Light and Power Supply Company of Australia remains to be reckoned with, and we believe it will be found that this company will not amalgamate, but fight. The figures set out so invitingly as the estimated revenue of the new company are, we contend, purely imaginary; the directors have no definite evidence that the extension of the central station in Melbourne will ensure them an annual revenue of £25,500. We advise shareholders to be very cautious in dealing with this reconstruction scheme, and to call for more definite information than has yet been vouchsafed them.

Direct United States Cable Company, Limited.

THE half-yearly ordinary general meeting of this company was held at Winchester House, Old Broad Street, E.C., on Friday, the 25th ult., Sir John Pender, K.C.M.G., presiding.

Mr. T. Finnis, the secretary, having read the notice convening the meeting, and the directors' report, which appeared in the REVIEW for January 18th, having been taken as read,

The Chairman said the revenue for the half-year to December 31st, after deducting out-payments, amounted to £34,188. The working and other expenses, including income tax, but exclusive of the cost of repairs, had been £16,476, leaving a balance of £17,712 as the net profit of the half-year. Adding the sum of £6,071 transferred from the reserve fund account for dividend purposes to June 30th (that was, to the end of their last financial year), there was a total of £23,783, out of which two dividends of 2s. each had been paid for the quarters ended June 30th and September 30th, leaving a balance of £11,641 on the revenue account. A further interim dividend of 3s. 6d. per share for the quarter ended December 31st, being at the rate of 3½ per cent. per annum, had been declared, and the dividend warrants would be posted that evening. There would then remain a balance of £1,017 to be carried forward. The revenue for the half-year—which included only four months at the shilling rate, the 6d. tariff having been in force up to the end of August—showed an increase of £11,185 over that of the corresponding period of 1887, but no reliable comparison was afforded by these figures, because the 6d. tariff was in force throughout the whole of the six months to December, 1887. The shilling tariff, however, had brought about some reduction in the volume of the traffic, as was naturally to be expected, but the earnings so far had been fairly augmented. The reserve fund account, after being credited with the interest on the investments and the profit on securities realised, and being debited with the outlay on the removal to Halifax and the cost of deep-sea repairs, now stood at £239,206. The special expenditure on the removal, and the deep-sea repairs, ought to be recouped to the reserve fund as soon as convenient. The investments continued, as heretofore, to be worth considerably more than they were stated at in the balance-sheet. With reference to the change in the rate, they had so far not been disappointed in the shilling tariff, though they did not get enough from it to pay a fair dividend. He hoped, however, that people who used the system—and the commerce of the world was now carried on more or less by submarine telegraphy—would get accustomed to the extra sixpence a word, and that the traffic would then go on increasing. They were giving the telegraphing public a fair trial at a very cheap rate, and he hoped that no alteration would be necessary in the future. He concluded by moving the adoption of the report and accounts.

Mr. William Ford seconded this proposition.

Mr. Jackson commented upon the great difference in the payments of this company for repairs and those for the same purpose made by the Anglo-American Telegraph Company, which, with more breakages, had expended far less money. He thought repairs should be tendered for, and that the contract should not always be given to the Telegraph Construction Company.

Mr. Guesdon spoke, deprecating the increase of the tariff, as he thought high profits always provoked competition. He also condemned the policy of awarding the contracts for repairs to the Telegraph Construction Company without tender.

The Chairman, in reply, said that they always invited tenders for the repairs of the cables, and submitted those tenders to the consulting engineers, Messrs. Clarke and Ford, who advised them to accept the tender which they did accept. There was no comparison between the repairs recently executed for this company and those of the Anglo-American Company. Mr. Jackson had been comparing, perhaps, the most important repair ever made in submarine telegraphy with the ordinary short repairs.

The resolution was carried, and the proceedings of the meeting terminated with a vote of thanks to the chairman.

The German Union Telegraph and Trust Company, Limited.

THE directors, in submitting their final report, state that the total receipts during the half-year ended January 25th, 1889, amount to £754 5s., which, with a balance of £156 3s. 5d. brought forward from last account, makes a total of £910 8s. 5d.

The expenses for the same period amount to £909 9s. 7d.; of this sum £750 is provided by the German Union Company of Berlin. The balance will be handed over to the liquidators.

On the 22nd January an extraordinary general meeting of the company was held, and voluntary liquidation was resolved upon. Sir James Anderson, chairman, and Mr. William Payton, secretary, were appointed liquidators. A confirmatory meeting to give effect to these special resolutions will be held immediately after the general meeting.

The liquidators will have the charge of distributing the assets receivable from Berlin in repayment of capital and interest. The liquidation will be conducted on the most economical basis. A first return of £7 7s. 6d. per share will be made forthwith, and the balance at the end of April, or in the beginning of May.

The directors now retire, and the liquidation will be made with all possible despatch.

The Metropolitan Electric Supply Company, Limited.

AN extraordinary general meeting of this company was held on Friday, last week, at the offices, Winchester House, Old Broad Street, Sir John Pender in the chair, to confirm the resolution passed at the meeting on the 8th ult., for altering certain clauses of the articles of association. On the motion of the chairman, seconded by Mr. J. C. Parkinson, the resolution was confirmed. The chairman afterwards stated that they were going on as quickly as they could with their installations. They had one working, and two others were in course of construction. His impression was that they would have more demands on them than they could supply for some time, but there would be no want of energy on their part to meet requirements.

India-Rubber, Gutta-Percha and Telegraph Works Company, Limited.—Subject to audit, the company's accounts to 31st December last show the following result:—

Brought forward from 1887	£9,530
Net profit for 1888	56,980
	66,510
Less interim dividend paid in July, 1888, 5 per cent.	20,800
	£45,710

The directors have resolved to recommend a further dividend of 5 per cent. (making 10 per cent. for 1888), and to carry forward £24,910.

National Telephone Company, Limited.—The accounts of this company, made up to December 31st, show a gross revenue of £117,726, as compared with £99,563, and the directors have declared a dividend for the six months ending December 31st last at the rate of 6 per cent. per annum on the first and second preference shares, and an interim dividend at the rate of 4 per cent. per annum (being at the same rate as for the corresponding period) on the ordinary shares, carrying forward £10,399, of which £3,500 is set aside against an outstanding claim. The unaccrued revenue carried forward amounts to £54,385 as against £45,826.

The Cuba Submarine Telegraph Company, Limited.—The report for the half-year ending December 31st states that the gross receipts (including the balance brought forward) amounted to £21,904, and the available balance to £15,508, of which £4,000 has been added to the reserve, increasing that fund to £84,000. The dividend on the preference shares will absorb £3,000, and the directors recommend a dividend on the ordinary shares at the rate of 9 per cent. per annum, tax free, £1,308 being carried forward.

TRAFFIC RECEIPTS

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending January 29th, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,550.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the last week amounted to £5,435.

ELECTRICAL TRACTION ON THE CITY OF LONDON AND SOUTHWARK SUBWAY.

THE method of construction and the system of working of the City of London and Southwark Subway, mark a new departure in the means of communication in our large towns and will probably afford a complete solution of the problem of underground railways.

The subway consists of two tunnels, each 10 feet 6 inches in diameter, formed of segmented cast-iron plates. It extends from the Stockwell terminus at Clapham Road, by the Oval and Elephant and Castle at Newington, and then under the Thames to the City terminus at King William Street, the total length of each tunnel exceeding 3 miles. There will be stations at the Monument, King William Street, Great Dover Street, the Elephant and Castle, the Oval and at Stockwell.

As the method of construction, which is entirely novel, has been already frequently described, we need not allude to it more particularly now, but it is only quite recently that the system of traction to be adopted has been finally decided.

The original Act of Parliament specified that the traffic should be worked by means of carriages, propelled upon the system of the cable tramway, but about a year ago the success of the Bessbrook and Newry Tramway, and other similar undertakings, led the directors to consider the adaptation of electrical working, and they entered into communication with Messrs. Mather & Platt, of Manchester, on whose behalf Dr. Edward Hopkinson, the managing partner of their electrical department, prepared a detailed and elaborate scheme. The matter was under discussion for some months, and finally tenders were invited from the most eminent electrical engineering firms. The result has been that the scheme of Messrs. Mather & Platt has been adopted in its entirety, as affording a perfectly satisfactory and feasible solution of the problem, and a contract has been placed with them for the carrying out of the entire work.

The generating plant will be placed at the Stockwell terminus, where boiler and engine plant of over 1,000 H.P. will be erected and three large Edison-Hopkinson generating dynamos. The current will be conveyed by a lead-covered cable throughout the whole length of the line, and Dr. John Hopkinson's system of overhead conductors will be adopted for conveying the current to the locomotives.

This system has proved a great success on a small scale at Bessbrook and is particularly well adapted for such an undertaking as the subway.

There will be 14 electrical locomotives, each capable of developing 100 H.P., which is sufficient for moving a train containing 100 passengers at 25 miles per hour, and for providing the great power required for starting rapidly. The trains will run at intervals of three minutes and each consist of three cars.

In addition to the plant required for electrical traction Messrs. Mather & Platt's contract includes the lighting of the trains and of the stations and of the hydraulic lifts and approaches.

The experience gained by Dr. Edward Hopkinson on the Bessbrook and Newry line, which, though on a much smaller scale, is still of the same character, and which has proved a most unqualified success, has solved many difficulties in connection with electrical traction, and will be of great value in the present undertaking.

Mr. James Henry Greathead is the engineer of the subway, to whose designs the entire works have been constructed. Sir John Fowler and Mr. Benjamin Baker are the consulting engineers, and Mr. Spagnoletti, the consulting electrician.

Manchester Microscopical Society.—The annual soirée was held in the lecture room of the Athenæum on Saturday evening. A lecture on "Electrical Phenomena in Animals" was delivered by Prof. W. Stirling. Electricity obtained from animals, he said, possessed all the properties of electricity generated in any other way, and he gave a description of the habits of the torpedo, the gymnotus, the malapterurus, and other fishes which have an electrical organ. The malapterurus had stronger electrical power than either of the other fishes he had mentioned. A tench, when struck by it, was stunned so completely that it rapidly turned on its side, and unless precautions were taken it would die. Frogs were rendered perfectly rigid and tetanic, and after a few shocks were passed through them, were killed. The animal had direct control of its electrical organ, and could regulate the power of the shock at will. The shock had no effect upon the brain of the animal which produced it.

Ocean Temperatures and Submarine Cables.—We have received a letter from Mr. Charles Bright on this subject, commenting upon the article which we published last week. Unfortunately it arrived too late for insertion in our current issue.

The Insidious Demon Gas.—Mr. Philip Newman, lamenting the destruction of a fresco of his at Belsize Square, is very bitter against "the insidious demon gas." He is in no doubt whatever that our descendants, at no remote period, will not have the art treasures which rejoice us now. He quotes also a dictum of the late Mr. Gambier Parry, that "nothing in the way of painting will withstand gas."

PROPOSED ELECTRIC LIGHTING AT PORTSMOUTH.

LTHOUGH the inhabitants of Portsmouth have for years past een acquainted with the great utility of the electric light, as roved by its adoption into the Royal Navy, it is a somewhat stonishing fact that hitherto no serious attempt has been made o supply the improved illuminant to the large business establish-ents. Messrs. J. D. Antill & Son, Messrs. G. S. Lancaster & Co., t Portsea, Messrs. Moody & Ellis at Southsea, and Messrs. Bishop ros. at Landport, constitute at present the whole of the local rms which have been enterprising enough to discontinue gas in avour of electricity. Within the last few weeks, however, a otable change has taken place in the attitude of the commercial lasses of Portsmouth towards electricity, and it having become nown that it was proposed to start an electric lighting company everal tradesmen at once signified their intention of lending the ovement their support, provided that the tariff of charges would ot be made too exorbitant. On Thursday evening a preliminary eeting was held at Southsea under the auspices of the South ants Electrical Supply Company, which has just opened an ffice in Elm Grove, with Messrs. J. H. Sandy (formerly local anager of the Western Counties and South Wales Telephone ompany), and R. Beveridge, as managers. There was a fairly epresentative attendance. Councillor McAskie was voted to the hair, and called upon Mr. Bate, chief engineer of the firm of essrs. Laing, Wharton, and Down, to deliver an address on lectric lighting, and on the practicability of its being introduced nto Portsmouth. After a brief sketch of the progress of electric ighting since its first introduction by Sir Humphrey Davey in 802, Mr. Bate addressed himself more immediately to an exposi-ion of the merits claimed on behalf of the Thomson-Houston ystem, which he mentioned was first introduced into Great ritain at the Inventions Exhibition of 1885. In the United tates the Thomson-Houston system had, he said, attained such re-eminence that on January 1st, this year, there were 440 ompanies using 59,000 of the Thomson-Houston arc lamps. The ividend paid by the various companies varied from five to twenty-ive per cent. Having referred to the introduction of the system n Bath, Exeter, Taunton, and many other English and foreign owns, he asked what was the reason for the Thomson-Houston system having made such rapid strides that they then ad more lights in the States (where they had been longer stablished than in this country) than any other company? t was due to the fact that the cost of production was less ith the Thomson-Houston than with any other system, wing to the fact that they had as a patent of the company n automatic regulator which was part and parcel of the ynamo. Their whole apparatus belonged to them, and they ad to go to no one to buy their electrical plant. Wires ould be run throughout the whole of Portsmouth, and the lectric light supplied to householders, &c., either by contract or y meter. One station would suffice for the whole town, and the ost of production would thus be considerably decreased. The ame staff which would be required to work a station with 100 ights could almost work one with 500. The question might be sked, "How can electric lighting be carried out in Portsmouth?" In reply to that he had told them how it had been accomplished n other towns, and it remained for them to say how far they would imitate the example which had been set them. Four years go he came to Portsmouth and saw many of the principal traders, ut things were not ripe then, and the matter had been deferred until now. In America electric lighting companies sometimes aid as much as 25 per cent., but such a dividend as that could ot be expected in a town like Portsmouth, where gas was so heap. They might indeed have some difficulty in getting the xtra price, but he reminded tradesmen that the electric light was more healthy than gas, and did not vitiate the atmosphere, poil goods, or disfigure the ornamentations of private houses, while at the same time it reduced to a minimum the risks of fire. In conclusion, he suggested that a provisional committee should be formed to feel the pulse of the trading community with reference to electric lighting. Messrs. Laing, Wharton, and Down would be pleased to assist any company which might be formed if there was any chance of success. From what he had himself seen he should say that 5,000 or 6,000 incandescent lamps could be easily put away in King's Road, Commercial Road, and Queen's Street, while 100 arc lights would also probably be required.

In answer to a question the CHAIRMAN said that the permission of the Corporation would no doubt have to be obtained before wires were erected overhead.

Alderman WEST said that hitherto the feelings of the Council had been strongly adverse to overhead wires, and he thought that permission to erect them would be refused. The wires would, he thought, have to go underground. At one time there would have been no chance for the electric light, owing to the constitution of the Council, but he thought there was a chance for it now.

A vote of thanks was passed to Mr. Bate, who, in reply, said that a 16 C.P. light would cost about ¼d. per hour, supposing that there was a reasonable number of consumers. If eighteen tradesmen, within a radius of half a mile, were willing to take an arc light each, his firm would undertake a month's experimental lighting at cost price, and, indeed, make no charge at all if the experiment led to the formation of a company with the necessary capital, say about £2,000. Messrs. McAskie, Lang, Thornton, Smith, Bulpitt, Sanderson, Ash, and Knight having been elected a committee of inquiry the proceedings terminated.

PROCEEDINGS OF SOCIETIES.

City and Guilds of London Institute Old Students' Association.

IN the unavoidable absence of the author the following paper was read by Mr. W. H. SNELL at a meeting held at the Central Institute on the 16th ult. "Notes on the design of electric motors." By ALSION T. SNELL.

In discussing the design of electric motors it will be necessary to first of all consider the relation between the dynamo and the motor. The dynamo may be defined as a machine which converts mechanical work into electrical energy. The motor, when supplied with electrical energy, gives out mechanical work. So far, one is the converse of the other, and the dynamo is said to be a *reversible* machine.

The extent to which this is true depends very largely on the size of the machine under consideration. This follows from the fact that no matter how bad the design of motor, how weak the field, or how small the magnets or armature, it is sure to *run*. But a badly designed dynamo—one with relatively weak field-magnets say—will often not excite at all. Or, again, the proportions of armature and field may be relatively correct, but the mass so little that the like result obtains. Why is this, if the dynamo be a reversible machine? It has been shown that the reactions in the dynamo armature are not the same as those in the motor. And it is now generally admitted that the effect of self-induction in the dynamo armature is to increase the lead, while in the motor it tends to diminish it. And Mr. Mordey has pointed out that in the generator the effects of self-induction in the armature windings are opposite to those of the Foucault currents in the core; but in the motor they tend to increase each other.

The writer has had these differences brought under his notice very forcibly in the course of his experience, having been connected directly or indirectly with the design of more than 400 machines, varying in output from ·1 horse-power to 100 horse-power.

The chief cause of this difference between dynamo and motor is to be found in the mutual effects of armature and field. Profs. Ayrton and Perry so far back as 1883 showed, both mathematically and practically, that in the motor the magnetism of the armature and that of the field *might* be added; in fact, the motor effort is proportional to the magnetic strength of both armature and field-magnets, while in the dynamo the field due to the armature, considered as an independent magnet, must necessarily subtract from that of the field magnets. These main distinctions occur in the nature of things. Their magnitude at first seems to be considerable; but really the effect depends very largely on the actual dimensions and the relative proportions adopted.

An ideal dynamo has an armature with neither internal resistance nor magnetism *per se*. The field magnets alone are the source of lines of force. This condition may be the more nearly attained as the size and weight of the machine be increased. All text books tell us that the field magnet should be as powerful as possible, and the armature relatively weak. The exponents of the "reversible theory" and its corollary, "the better the dynamo the better the motor," appear to have had more experience of large machines than small ones. And their *experimentum crucis* necessarily leads them to such views. When such authorities as Hopkinson and Silvanus Thompson, Kapp and Mordey, assert anything electrical, few venture to disagree. But I beg to submit that an extended experience with small and medium size machines would modify their views, especially if weight efficiency be an object in the design.

Be this as it may, a motor weighing 70 lbs. can be made to give a B.H.P. with 70 per cent. efficiency of conversion; but the same machine run as a dynamo would require nearly 50 per cent. more speed to give an output of 746 watts, and even then the efficiency between output and belt power would be nowhere near 70 per cent. If this be true, and I think it beyond dispute, the theory and corollary require some modification. The approximation to the same efficiency when used as a dynamo or motor becomes the more apparent as the size of the machine is increased; but even up to 50 H.P. I prefer to make certain structural differences in the design of dynamos and motors, particularly if they be series wound. With shunt machines the difference seems to be less marked owing to the field being more nearly constant. If I mistake not, both Hopkinson and Mordey have founded their opinions on observations made from large shunt machines.

Much more might be said on this branch of the subject, and numerous actual experiments might be given in support of my views, but this would digress too much from the object of this paper. With these introductory remarks on the character of motors and their relationship to dynamos, I will pass on to the general design of motors.

There are two broad lines on which motors can be designed. They depend entirely whether weight and overall dimensions enter into the problem. It is only necessary to admit that a powerful armature with many ampère turns and a relatively weak field will give the same torque as a strong field and a weak armature. Granting this, we can design a motor to give a certain torque independently of the total weight to some very considerable extent. We shall be guided in the proportion of armature and field by the work expected of the motor, by the price allowed for production, by the intended cost of future maintenance, and by the desired life. These two methods of design depend on the point of starting. In the *first* we take an armature of given size, select a certain surface velocity, and build the field as small as possible to give the desired torque. In the *second*, a certain type of field iron being determined on, we select an armature of sufficient cross-section to give the required results. The first of these two methods is by far the more scientific, inasmuch as the dimensions of the most costly part of the motor can be made a minimum. The second method, however, will sometimes occur in practice, and it is well to note the possible results of this as well as those of the more general case.

When designing a motor to do particular work the following points should be considered :—

1. What is likely to be the average torque on the motor and driven shaft?

2. Is the motor to run continuously or only for short periods at more or less frequent intervals?

3. What variations of load may be expected?

4. What will be the maximum torque on the motor shaft?

1 and 4 will determine the characteristic of the motor and the particular part of the curve at which the average torque shall be arranged to fall.

4 will determine the size of the shaft and strength of the bearings.

1 gives us the ratio of the speeds between the motor and the driven shaft.

2 and 3 determine the limiting safe rise of temperature, while the winding must be designed to satisfy all the conditions as nearly as may be.

It is not possible within the limit of a short paper to thoroughly analyse the different points to be observed. The general method can alone be indicated, and experience must teach the engineering student the rest. I will roughly run through the several conditions of design, and give such hints as appear likely to be of use.

The first thing to be noted is the torque on the driven shaft. This is not always an easy thing to get at owing to the want of a little scientific nous in the ordinary mechanic. If, however, this be known it is possible to determine within a few per cent. the required current, and the best ratio of gearing to get a maximum average efficiency from the motor. If this be accomplished the motor will be a success. If the motor be designed on the assumption of so much horse-power being required, and gearing be accordingly selected, it probably will happen that, though the estimate of power be fairly correct, the motor will be unsuited to the work. The current, and consequently the torque on the motor shaft, will probably be excessive. The efficiency of the motor will thus be low, and the electrical horse-power absorbed excessive, while, further, the speed will be too slow. The obvious remedy would be an increase in the ratio of the intermediate gearing. But if the surface velocity of the motor be correctly designed the increased speed will be too great, and, consequently, introduce other difficulties; in fact, the motor will be a failure—not from any intrinsic fault, but simply because improperly designed for the work.

Daily one comes across machines driven by electricity, steam, air or water, in which the same fault appears. The speed of the prime shaft is not properly proportioned to that of the main or driven shaft. The consequent loss in possible efficiency is oftentimes not known, or if suspected, is ignored. This sort of thing did well enough years ago; but addressing a body of educated men who are likely to occupy leading positions among the engineers of the immediate future, I cannot pass it by without protest. I therefore beg to impress on you the necessity of determining in some way or other the actual number of foot pounds required to make one revolution of the main shaft. Your ingenuity will suggest many ways of doing this in most cases.

As an illustration of my point, I will mention the many attempts to run electric tramcars by direct gearing, *i.e.*, without a countershaft. Nearly every firm that has tried the tramcar problem has made the attempt. One of the latest has been the Sprague motor line at Richmond, United States. That the method is unsatisfactory and can be much improved on there is no doubt, for Mr. Sprague has already (October 2nd), 1888, published drawings of a new tramcar involving two motors with *countershafts.*

Engineers using electric motors seem to forget that a motor, although very efficient at or about a certain speed, is most inefficient at low speeds (*vide* curves).* Too much stress is laid on the property of a motor exerting maximum torque at starting. It is forgotten that the efficiency is *nil* under the condition of maximum torque, and that it increases very slowly until the point of 50 per cent is reached. There are other sides, of course, to the question; but I wish here to strongly emphasise the primary condition of motor design, viz., attention to the torque of motor and main shaft.

Having, then, determined the torques of the system the ratio of our gearing is known. Let us suppose that the motor torque be $\frac{1}{10}$th that of the main shaft, and that the gearing be accordingly in the ratio of 1 : 10. We have now to select an armature that will give us this torque at the speed required, satisfying also the conditions of durability, and that the rise of temperature will not exceed a certain limit, say 60° F., above the temperature of the room.

The mathematical expression for the torque of a motor is simple. Let T be the torque. The output required of the motor at n revolutions per minute is, say, 1 B.H.P.

Then,

$$T = \frac{\text{B.H.P}}{2\,\pi\,n} = \frac{33{,}000}{2\,\pi\,n} = \frac{5{,}280}{n}\ \text{lb. ft.} \qquad (\alpha)$$

That is, the moment of the forces tending to turn the armature is equal to $\frac{5280}{n}$ lbs. acting at a radius of 1 ft.

To get the exact pull on the periphery, it will be necessary to multiply this quantity by the ratio $\frac{1}{r}$, where r = the mean radius of the armature in feet.

The tangential strain on the wire is therefore

$$= \frac{5280}{n} \cdot \frac{1}{r}\ \text{lbs.} \qquad (\beta)$$

This latter quantity is what we require in designing the motor. In order to obtain the desired couple on our armature, we make

$$T = \frac{Z_a\,N\,t\,C_a}{2\,\pi\,r} \qquad (\gamma)$$

where Z_a = the number of lines of force passing through the armature, N, t = the number of turns of wire counted all round, C_a = current flowing in any one coil of the armature, *i.e.*, half the total current, and r = mean radius of the armature core. It will be noted that the field does not come directly into the question. The function of the field magnets is only to supply a magnetic field. It will be our care to so arrange the magnets and their windings that the proper value of Z_a is obtained. This is all that is necessary now. I shall have occasion to comment on this assumption later on when considering the field.

(*To be concluded.*)

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* Curve, E, E is the values of the E.H.P. for the different speeds, the motor running at constant potential. O, *s* is an approximation to the corresponding B.H.P.; and O, F, F is the commercial efficiency (plotted to another scale). It will be noted that the efficiency increases at first with the speed, and, after attaining a maximum, slowly decreases, having passed through two points of 50 per cent. efficiency.

THE KENSINGTON STATION OF THE HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY, LIMITED.

A NEW station for the House-to-House Electric Light Supply Company has been erected on ground adjoining the District Railway Station, in the Richmond Road, West Brompton. The plot of ground on which it is built is well adapted for the purpose by its position, for its boundaries being on one side a railway line, and on two others the cemetery wall, with only a small frontage at the Richmond Road, no annoyance to neighbours can be caused by the noise or vibration of machinery.

On Wednesday last, the 24th ult., this station was opened, and a large party of gentlemen interested in electric lighting, and deputations from several seaside towns, were shown over the works by the officials of the company, who pointed out and explained the most salient features of the system to be employed in supplying the electric current to the surrounding neighbourhood.

The majority of the visitors attended later on in the evening a banquet given by the company to inaugurate the opening of its first central station in London. This dinner was held at Bailey's Hotel, Gloucester Road, and notwithstanding the execrable nature of the French in the *menu*, the viands themselves proved to be of high class and excellently served. Success to the company was the toast of the evening.

The frontage of the central station in Richmond Road is taken up by the offices, and is designed to correspond with the elevation of the adjoining railway station. They consist of a public hall, engineers' and company offices, and show rooms. At the back of the offices, on a piece of ground between the latter and the engine house, stores, stables, repairing shops, &c., are erected, the coal store being covered by a cast iron tank, seven feet in depth. Access to this yard is gained through a gateway leading from the main road.

Beyond this yard we come to the boiler house, which is separated from the engine house by the switch and regulating room, the testing room, stores and office for the engineer in charge; the engineer's office is upstairs, and having windows on both sides, commands a view of both boilers and engines.

The plant at present in place consists of three sets of engines, dynamos, and exciters. The engines, made to specification by Messrs. John Fowler & Co., of Leeds, are of 200 H.P. each, and are of the horizontal coupled compound type, the initial steam pressure being 150 pounds per square inch. The revolutions of the engines are 88 per minute.

The Lowrie-Parker dynamos, driven from the fly-wheels of the engines by seven ropes, were manufactured by Messrs. Elwell Parker & Co., and are multipolar alternating current machines, having an output of 100,000 watts. Speed, 380 revolutions per minute; E.M.F., 2,000 volts. The exciters are 12 unit machines by the same makers, series wound and running at a speed of 800 revolutions per minute. Efficient means are provided for tightening the driving ropes on dynamos and exciters.

The 250 H.P. boilers supplied by the Babcock and Willcox Company evaporate 10½ pounds of water for 1 pound of Welsh coal. The chimney shaft, common to all three boilers, is 100 feet high, with an interior diameter of 5 feet 6 inches.

The terminals of the high tension dynamos are all hidden in the frame and the wires taken through a trench in the foundations and through a covered main trench, common to all the dynamos, to the switch-room behind a screen. The switch-blocks are mounted on this screen, and the connections made behind, so that no wires are visible in the switch-room. The E.M.F. of the dynamo is regulated by the Lowrie-Hall system, embodied in an instrument where the thermal effects of the currents acting on a thin wire gives sufficient motion to place a shunt of varying resistance across the fields of the exciter.

The main switch-board is of slate, with terminals covered with porcelain bosses projecting some distance beyond the terminals to protect these from dust, dirt and the like, and to prevent accidental contact. The bosses have orifices in the front for the insertion of the contact plugs, and these latter are fastened to an insulating board having a handle at the back.

The means used to test the general insulation of the mains consists of a vacuum discharge tube, enclosed in a small box, pierced with a sight hole with suitable terminals, one connected to earth, the other to the conductor to be tested; the degree of luminosity produced gives a good approximate idea of the insulation state, the light dying away as the insulation diminishes.

The mains are protected from injury by a system of underground conduits, consisting of cast iron piping with draw-boxes at intervals. The pipes forming this conduit are the ordinary cast iron gas tubing, in three diameters, suitable for the service intended, the piping varying in the bore from 3 inches to 6 inches. At every seventy yards, or thereabouts, the pipes are bolted to a draw box by means of a flange on the end of the length of the tube butting on the box, the flange being cast of precisely the same pattern and size for the 3-inch duct as for the 6-inch. No particular care is taken to have the several joints rendered water-tight, the construction being intended merely as a mechanical protection, and it is not, therefore, of any importance or consideration that the channel should be kept dry. In point of fact, Mr. Lowrie has designed his underground system with the purpose not to exclude water from entering the pipes, but rather to let it drain off as quickly as possible. In view of this, the draw-boxes are cast without bottoms, the foundations for which are excavated to some depth, then partly filled with gravel, and the frame or box is bedded down on the latter, which allows any water entering the box to percolate rapidly away. All draw-boxes have a lid to carry the traffic secured when in use to its framework by a pair of spring locks, the keys to open which form also handles by which to lift off the lid. It frequently occurs that the surface of a street is either raised or its camber is altered; should this take place, unless provision had been made, the entire box would have to be raised to the new level, and the expense would be somewhat heavy. To avoid this, the upper part of each box is constructed separate from the under-portion, and the two portions are cemented together, the upper piece being adjustable to any desired position. Thus, when further interference with the roadway is contemplated, no difficulty arises in the readjustment of the lids, as this simply means chipping out the cement and re-fixing.

Distributing boxes are to be placed opposite every two houses, and in the event of the main in one of the distributing boxes becoming faulty, the bad lead can be cut out, and the service to the houses put on to the main at the adjoining distributor.

The cable to be used is very similar to that called, in America, the "Patterson," that is, a copper core, cotton covered, steeped in some insulating material, and a sheathing of lead over all, except in certain cases where a protection of platted hemp is added over the metal covering, to save the lead from accidental abrasions during the laying and manipulation of the mains, when drawing the cables into the cast iron pipes.

Messrs. John Fowler & Co., of Leeds, are the manufacturers of this special type of cable, which, instead of being made with yarn covering and an external braiding of cotton as in the ordinary manner, is entirely covered with successive layers of braiding impregnated, the term by which the makers indicate the saturation of the covering with the insulating compound, until the required depth of insulation is put on. This depth is approximately a quarter of an inch for the large mains, the conductor of which consists of 19 strands of copper wire, ·077 inch in diameter. After thorough impregnation, the cable is drawn into a lead covering, and finally finished with a coating of tarred hemp braided on.

The insulation of the main cable was tested at Messrs. Fowler's works, and gave a resistance of 35,000 megohms per mile. Five sizes of the above class of wires will be used by the House-to-House Lighting Company :

3-wire	cable.	Conductor	·043	of	an inch	in diameter.
7	„	„	·045		„	„
7	„	„	·064		„	„
19	„	„	·055		„	„
19	„	„	·077		„	„

These cables can be manufactured in one piece to any length stipulated by the customer, but it is found generally more convenient and handy for working in lengths of about a quarter of a mile. In practice at Eastbourne, there has been laid down, in one unbroken piece, a cable extending 900 yards; such a line, however, can only be economical under conditions seldom occurring.

Where a branch wire is joined to another at right angles, an ingenious method is adopted of making good the lead covering. Having made the joint in a sound manner, and carefully insulated, the whole being finished to the diameter of the cables, an oblong plate of lead, wide enough to extend about 2 inches on each side of the splice, is doubled over the back of the cross part of the joint, so that the free ends of the plate may extend some 2 inches on the branch wire; then by a special tool the metal is compressed over the cables exactly taking their form, and leaving a strengthening web in the angles of the T, and the lead sheathing is next soldered or burnt on to the original covering; the joint thus formed is possessed of much rigidity, and can be roughly handled without danger of rupture or other disaster.

From the distributing boxes the house mains are carried to the converter, which may be either put inside the house or just outside; before reaching it the house mains pass through a safety fuse mounted on porcelain, from thence to a main switch, also mounted in porcelain, and in principle similar to those employed in the switch-room at the central station. The customer can, if he sees occasion, entirely sever his house from the company's mains by means of the switch which passes the current to the converter for reduction to lower potential for domestic consumption.

The transformer is of the type known as the Lowrie-Hall, and is constructed with two cores formed of thin iron plates insulated from each other. A primary and secondary coil is wound on each of these cores, the two coils are then placed side by side, and the ends of the iron cores, which project beyond the copper coils at both extremities, are turned over alternately, each pair of plates being well insulated from the next. The whole of the plates at each end are tightly clamped together to ensure good magnetic contact and form a closed magnetic circuit. The percentage of conversion by this pattern of converter was not stated, but presumably it will satisfactorily compare with other forms.

Every house is to be provided with a meter, the record being obtained by the deposition of copper, which is accomplished by the differentiation of the alternating electromotive force in the leads from the converter. The apparatus adopted by the company consists of a secondary cell and a deposition cell; it is insulated from and contained in a cast iron case, with a screwed down cover, the cables entering through insulating washers. The main is severed as it proceeds from the transformer to the lamps, or other appliances in which the energy is expended, and the meter put across the break, so that the whole current to be measured passes through it. The current on entering the meter passes through the secondary cell, whose electromotive force = 2 volts, so producing a differentiation in the positive and negative directions in half of an alternation. That is to say, that supposing the electromotive force of the converter to be 100 volts and the mean current to be 10 ampères, then in the half-alternation positive to the constant cell at its maximum point, the total electromotive force = 202 volts, therefore the maximum current $= \frac{202}{10} = 20{\cdot}2$ ampères, while in the other half-alternation total resultant electromotive force = 198 volts and the current = 19·8 ampères, thus giving an effective current of ·4 ampères. But this current lasts for only one-half of an alternation, in the same way that an alternating current does, therefore the average current is only ·2 ampères for the whole time, or, which is the same thing, a current due to 2 volts only. The application of this effective current takes place in the depositing cell, which is a cell in which the electrodes are of copper, alternately connected together, and the solution a slightly acidulated saturated solution of recrystallised sulphate of copper in distilled water. The resistance of this cell is considered quite unimportant, the area of the plates being large.

The quantity of copper deposited during the consumption of 1,000 watts or one unit in the exterior circuit will be = ·2354 grammes, and the makers calculate that this is correct within 2 per cent., so that the meter works to an efficiency of 98 per cent. A full and illustrated description of this meter was given in the REVIEW for September 21st, 1888.

The quantity of electricity consumed by a customer will be measured quarterly, and the following charges, on the sliding scale basis, will be made, varying with the maximum supply demanded by the user :—

1. At the rate of 1s. per Board of Trade unit for the first 100 hours' consumption of the maximum supply demanded.

2. At the rate of 8d. per Board of Trade unit for the second 100 hours' consumption of the maximum supply demanded.

3. At the rate of 4d. per Board of Trade unit for any further quantity consumed.

There will also be a charge of 5s. per Board of Trade unit per quarter for the use of the meter, instruments, &c. The company has made applications to the Board of Trade for a provisional order for powers to lay mains throughout all the streets and thoroughfares in the parish of St. Mary Abbott's, Kensington, except those comprised in the licence already obtained by the Kensington Court Company. Pending the granting of this order, permission has been obtained for carrying the mains through private property, and about 40 houses are being fitted up, which the company hopes will be ready for service in a few weeks.

The engineer of the company, Mr. William Lowrie, has had much experience at Eastbourne respecting the practicability of an underground system of electrical distribution from a central station, and the Kensington Station of the House-to-House Electric Light Company has been erected to work a system under similar conditions, but with appliances of a more perfected character. In examining these in their details, and as a whole, we were greatly impressed by the skill displayed in their design, and by the thorough and workmanlike manner in which they were carried out. We observed also with pleasure that the testing instruments were not put in some out of the way corner or in an inconvenient position, but that a proper room on the ground floor was set apart for their erection, containing a brick pillar, for the Thomson galvanometer, the foundation being carried many feet below the soil. The insulation resistance of the circuits which were then in use averaged about 8 megohms. All the care that has been bestowed on this installation should command success from an electrical point of view, and then the company, we trust, will reap a commercially successful harvest. This is all the more to be desired, for it is highly necessary that something should now be carried to a successful issue to make amends for such lamentable failures as those which have discredited the towns of Leamington, Barnet, and other places we could name. We hope that the time has now come when central station lighting may be considered as likely to command success, and that our American contemporaries will no longer be able to taunt us with the enumeration of our miserable failures.

ELECTRIC METERS FOR CENTRAL STATIONS.*

By Prof. GEORGE FORBES, F.R.S.

THERE is no department of electric engineering which has interested me and occupied my thought more than that of central station work, and the distribution of electricity from these centres throughout a town for the production of light and power.

Both in Europe and America there is one maxim which I find is conclusively established. This is, that the best paying stations are those in which the electricity is charged for by meter, and not at so much per lamp per annum. Both these systems are in use, but companies who have used both give their undivided testimony in favour of charging by meter.

Now, first let us settle the question what it is we want to measure.

With electricity, when we have measured the quantity consumed, there is only one quality which can exist, and that is its pressure. If, then, our meters measure the quantity consumed, and inspectors keep watch to see that the pressure is always maintained constant, the consumer's interests are amply looked after.

Now, it has been suggested that we really ought to measure, not the quantity of electric current which is consumed, but the quantity of energy. Now, the energy is the product of the quantity by the pressure, and could easily be measured if desired. There would be no object, however, in doing this. A deficiency of pressure is certainly undesirable, because the lamps burn less brightly, and the customer should be charged less. But, on the other hand, an excess of pressure is equally objectionable, because it injures the lamps, and it would not be fair to charge the customer more for the quantity he uses under these conditions. The only fair way is to do as with gas—*i.e.*, to measure the quantity used and guarantee the quality—*i.e.*, the constancy of pressure. This should never vary more than 4 or 5 per cent. at the most. For perfect lighting a variation of 2 or 3 per cent. only can be allowed.

I intend to direct your attention to various kinds of meters which have been put into actual practice, but before doing so it will be well to point out some of the *desiderata* in a perfect electric meter. I will deal with these in order.

1. *Accuracy.*—The meter must be at least as accurate as an ordinary gas meter. In fact, that standard is rather low for modern requirements. The question of accuracy is two-fold. First, the readings of the meter must be accordant for all rates of supplying electricity within its range; and, secondly, the indications of different meters must be consistent. This latter point is largely one of manufacture, so that it must be easy to manufacture the instruments in large quantities, all exactly similar.

2. *Range.*—It is desirable that the meter should be capable of working accurately over a large range of current strength. It would undoubtedly be desirable that the meters, made for the largest currents which can be used on a circuit, should also be capable of indicating correctly when only one lamp is in circuit. So far as I am aware, no electric meter has been invented fulfilling this requirement. It has often been proposed, with circuits of very many lamps, to have two meters—one for small currents and the other for large ones—and to switch in the latter automatically when the current exceeds a certain amount. Any such arrangement, which involves an occasional use of a contact-breaker, is objectionable, owing to the sparking and consequent deterioration of the contact. A far better plan, in the existing state of things, is to wire the houses in separate circuits of 20, 40, 60, or 100 lamps, according to the effective range of the meter adopted.

3. *Consumption of Energy.*—Energy must not be consumed by the meter to such an extent as to diminish injuriously the voltage supplied to the lamps. The wiring of a house diminishes the voltage at the maximum about 2 per cent., according to present practice. A meter ought not to increase this loss by more than ½ per cent.

4. *Simplicity.*—The meter should be simple to construct, and not liable to get out of order. Extreme delicacy in moving parts is to be avoided when possible.

5. *Durability.*—It is essential that no parts of the apparatus are liable to wear out rapidly.

6. *Attention.*—Other things being equal, that meter is the best which requires least attention. Any winding up of clockwork is objectionable, and the necessity of removing the meter or part of it from the consumer's premises should be avoided.

7. *Registration.*—The meter should register in a clear manner, so that the consumer can read it any time and check its accuracy. A system of geared wheels with indexes and pointers, like a gas meter, is very convenient.

8. *Testing.*—A point of some practical value is that it should be an easy matter to test the meter, and that the operation should not occupy much time.

9. *Cheating.*—With some meters the process of cheating is easier than with others. The possibility of short-circuiting the meter is common to all, and can be obviated. Some meters can be retarded by placing a magnet near them; others by heating them, others by putting them out of level. This last can be prevented by securely fixing the meter to a wall or floor.

10. *Economy.*—A meter will not be practical if it entails a large rental, and so adds much to the quarterly bill.

11. *Freezing.*—A meter which contains a liquid which can freeze is objectionable in any but warm countries, since a lamp or other resistance must then be put inside it to keep it warm, and this is a constant source of waste of energy.

12. *Alternating and Continuous Currents.*—Some meters are only usable with continuous, others with alternating, currents. A meter which reads with equal accuracy for both kinds has a double value. Many stations supply both classes of currents, and it is less inconvenient to deal with only one type of meter.

13. *Number of Alternations.*—Meters for alternating currents ought to indicate with equal accuracy, whatever be the number of alternations per second. Otherwise irregularities will occur, and also the supplier of electricity can cheat by altering the number when under test, and also when at actual work.

14. *Contract-breaking.*—No contact-breaker of any electric circuit should be allowed in a meter, because such contracts deteriorate with use.

15. *Mailing.*—The meters should be so substantial that they can be sent by rail without accident.

No one meter fulfils all these requirements perfectly. But all the meters which I am going to describe fulfil many of them, as they all have done good practical work on central stations.

In all the meters which I have to describe, the registration is effected either by moving mechanical parts, or by electrolytic decomposition. In most of the mechanical meters a certain dynamical principle has been employed to guide the inventors to an accurate instrument for different strengths of current. I will now explain this. In the class of meters I allude to, the electric current sets some mechanism in movement. Now we all know that generally the work done by a current in a given time varies as the square of the current. Thus the electrical force tending to drive the mechanism is proportional to the square of the current. Such mechanism would increase its speed indefinitely under the influence of such a force if there were no friction opposing the increase of speed. In the meters I allude to the friction of the air or of a fluid is opposed to the driving force of the electric current. This resistance increases as the square of the velocity. The electric force goes on increasing the speed of the mechanism until the opposing friction equals the driving force of the electric current. But the friction varies as the square of the velocity, and the driving force varies as the square of the current. Hence in all cases where the mechanism acquires uniform speed the square of the velocity is proportional to the square of the current; in other words, the velocity varies as the current. Now, the indications of such an instrument as shown by an index gives the number of revolutions of the mechanism in the period of testing, which means the velocity multiplied by the time, and this is proportional to the electric current multiplied by the time. Hence the index marks the total number of ampère hours, or the total number of Board of Trade units which have passed through the instrument.

Edison Meter.—In describing the different meters, I will begin with the Edison meter, not only because it was the first to be used, but also because it has done a larger amount of useful work in central stations than any other meter.

[Prof. Forbes here went on to describe briefly the Edison apparatus, which have been exhaustively treated in our columns during the past few weeks.—EDS. ELEC. REV.]

The range within which the meter is said to be accurate within 3 per cent. is from 5-fold to 10-fold, *i.e.*, if 1 ampère is the lowest current for which it is accurate, then 5 or 10 ampères is the maximum current for which it is accurate.

Now, you may say that this is not exactly the kind of meter we require, because customers cannot check the weighings, and are absolutely dependent on the good faith of the company supplying the electricity. It has also been argued that the shunt arrangement cannot be perfect with varying temperatures. Well, I can only say that the meter in practice is found to do good work. I agree entirely with what Mr. Edison said to me about it. He said:—"It is not an ideal meter, but it is simple and effective, and gives general satisfaction wherever it is used." I endorse this opinion. But the managers of central stations where it is used have given me higher estimates still of its value. They say that customers are all quite content with the manner of reading it. As to accuracy, many customers have kept accurate tally of the lamp-hours which they have consumed, and compared it with the charges by meter, and have often come within 2 or 3 per cent. At the splendid central station at Milan, which I lately visited, this meter is in constant use, and is much appreciated by the company. They say that the expenses of maintaining the meter department are not large when the whole thing is well organised. The total number of ampère-hours sent out from the station, as measured by the amperemeters, agrees with the meter accounts within 3 per cent. This station, which I have carefully inspected, is an admirably conducted one, and embraces three systems, the Edison low-tension, the alternating high-tension, and the Thomsom-Houston arc lamp systems.

Ferranti Meter.—The next meter which I wish to describe is that of Mr. Ferranti. It is one so beautifully simple in its principle as to please at first sight. It is founded on the principle that when an electric current passes through a fluid which is placed in a magnetised space, the fluid tends to move in a direction perpendicular to the current and to the magnetic action. Two magnetic poles of circular form are placed one above the other, one being a north pole, the other a south pole. Between these two is a circular insulated trough containing mercury. The current enters the mercury at the centre of the trough, and the outer rim of the trough forms the other electric terminal where the current goes out

The original instruments were intended for currents continuous in direction, and the magnets were excited by the electric current to a moderate amount, so that the magnetism was proportional to the current. Thus the moving force was proportional to the square of the current, and the friction of the mercury being approximately as the square of the velocity, the indications of the instrument would be accurate. Of course, the law I have spoken of is only true as a sort of approximation. The friction of the indicating mechanism follows a different law, and affects the result. The number of rotations made by the mercury is indicated by the rotation of a float of special construction, resting on the mercury, connected by a spindle, with a train of wheelwork which indicates the total number of revolutions. This meter has also been adapted for alternating currents, and is rendered more delicate by having an additional shunt winding of very high resistance. This circuit is put in multiple arc with the lamps on the two mains of the house supply. The friction of the wheel train is reduced to a minimum by employing the finest and lightest mechanism which can possibly be constructed. I am sorry to say that Mr. Ferranti has not been able to furnish me with any tests or specimens of his alternating current meter, as he is even now introducing some improvements. I am told the range is about 50-fold, and that it is very accurate. I may mention, in praise of Mr. Ferranti's ingenuity, that both Mr. Edison and Mr. Weston, in America, two of the most prolific inventors, tried to work out a similar instrument and found it ineffective. The chief difficulty was one which, until Mr. Ferranti attacked the problem, has been taken as a universal fact, viz., that mercury is unsuited for a permanent contact. They found that the mercury got covered with a film or powder which interfered with its free movement.

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* Paper read before the Society of Arts on Wednesday evening, January 23rd, 1889.

*Aron's Meter.**—I now come to a very interesting type of meter, the principle of which was first suggested in this country by Profs. Ayrton and Perry, and which has been made a practical instrument by Mr. Aron, in Germany. I have lately visited the central stations of Berlin, the largest on the Continent. These stations are the best equipped in the way of boilers, engines, dynamos, and accessories of any low-tension system I have ever seen. There is this defect, however, that they have hitherto used a distributing system with two instead of three wires. This fault will be remedied in the future. They supply, at present, current sufficient for a maximum supply of 26,000 incandescent lamps of 16 candle-power. And here let me protest against the practice, beginning in this country, of taking an 8 candle-power lamp as the normal one. Everyone is dissatisfied with the low candle-power prevalent in London, and, as a general rule, 16 candle-power lamps have been found in actual experience in hundreds of central stations to be the most suitable. The stations also light the Unter den Linden with 108 arc lamps of 15 ampères, and the Leipsiger Strasse with 36 arc lamps. The former is the finest piece of street lighting ever accomplished.

All the incandescent lamps are charged for by meter, and the Aron meter is always used. In the Berlin central stations the authorities speak in very high terms of its value. Complaints from customers do come in, but in these cases the meters are tested, and found to work quite well. Its range is greater than for any other meter, being about 100-fold, I believe.

This meter has been altered, to adapt it for registering alternating currents, by replacing the permanent magnets by coils, or electromagnets. In the central station at Rome, which is in many points the finest and best designed station for alternating currents which I have yet seen, it is intended to test these meters. But I can say nothing about their accuracy. I will only point out that in this case the retarding influence varies as the square of the current, whereas, with the permanent magnet, it varies as the current. This does not lead us to hope for the same satisfaction as is afforded by the type for continuous currents.

(*To be continued.*)

LIGHTNING ARRESTERS AND THE PHOTOGRAPHIC STUDY OF SELF-INDUCTION.†

By E. G. ACHESON.

IF in the opinion of any an apology is required—and it is thought that such will be the case—for thus presenting a subject that is in many of its parts a reproduction of the experimental work of such authorities as Prof. Hughes, Prof. Lodge, Dr. Hertz and others, the excuse is offered that the original motive thought when entering into the series of experiments referred to in this paper was a legitimate one—the clearing away of a little fog surrounding some annoying phenomena attending the working of cables of electric conductors. The investigations became so interesting, so striking and suggestive, and some of the results appeared to have such a value, that it was believed they would afford sufficient excuse for this presentation.

While the measurements made during these investigations were not as accurate as it would be possible to obtain with more refined instruments, the probable errors were not so great as to make them wholly valueless, care in the readings and many determinations checking to a great extent the errors due to the crudeness of the apparatus. Appreciating the fact that untruthful results are less desirable than none, owing to their misleading effects, it is intended to impress the fact that the determinations contained in this paper can at best only serve as a possible check upon future work of a more complete and accurate character. It is also to be hoped that they may promote the already lively interest displayed by the scientific world in discharges, and the sometimes oscillatory character of electric currents.

The mass of material and composite character of the work to be presented will necessitate considerable care in selecting the order of presentation, and it is believed that the subject can be more easily followed if the thoughts and experiments succeed each other in the order in which they occurred to the experimenter, and this plan will be followed even when the afterthought is of the greater importance.

As previously stated, the primary motive from which followed this series of experiments, was the clearing up of some uncertainty as to the cause of a few annoying troubles in electric cables. But, to be more precise, it was desired to determine the cause of the occasional "grounding" and failure of cables used in telegraphic and telephonic service, when to all outward appearances they were perfect in construction, protected with lightning arresters, and immediately before the moment of grounding indicated high insulation resistances. A case of this kind presented itself for solution, in which there were some features of peculiar attraction to an investigator. It was a cable containing five wires about one mile in length, and of that design known as anti-induction, the cross-section being star-shaped, each conductor having a surrounding wall of lead. It was used for telegraph work, and the conductors were connected at the ends to overhead lines, lightning arresters being provided for the protection of the cable; the terminals of the cable were on poles some 20 feet in height. The ground plates of the arresters were connected to the earth in the usual manner; that is, by wires running down the poles to plates in the ground.

This cable was continually getting into trouble, the conductors becoming solidly "grounded," and upon examination it was found that the "grounds" were caused by little kernels or spots of carbonised insulation. It was at the first moment thought that these had been introduced in the manufacture of the cable, but their repeated formation emphatically declared against this theory, and made it imperative to learn the true cause. It was not probable that they were produced by the working currents, for they were of comparatively low electromotive forces, while the presence of the lightning arresters would, in accordance with the prescribed rules of their action, render it wholly unlikely that they could have been produced by lightning.

A close study of the experiments of Prof. Hughes on self-induction, and of Prof. Lodge on the "alternative path," had produced an unsettled condition of my ideas as to the true value of a lightning arrester. The work of these investigators, together with some few experiments of my own, had produced a feeling of interest as to the efficiency of even the best arranged arresters as connected in ordinary practice. I was prepared to believe this to be a practical live case of a well mounted and connected lightning arrester not protecting. It even seemed possible that the cable itself was, in reality, protecting the protector, when viewed in the light of Prof. Lodge's "alternative path" experiment.

In order to come to some definite and practical conclusions as to the possibility of these troubles having been produced by lightning, a series of experiments was undertaken on lines somewhat analogous to those of Prof. Lodge.

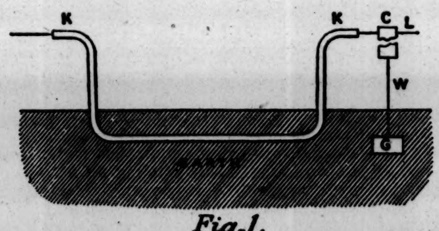

Fig. 1.

In fig. 1, the general and important conditions of a cable placed on the earth, and provided with lightning arresters as usually connected, are outlined. In the figure, K represents the cable, L the line wire, and W the ground wire connecting C to the ground plate, G.

It is generally supposed that lightning—or an electrical discharge, as I prefer to call it—produced by the difference of potential between the cloud above the wire, L, and the earth beneath, would, upon striking the wire, pass to the lightning arrester, C, jump across the space separating the points to the wire, W, and thence to the earth, or the reverse, as the case may be. But while this is probably the case in many instances, it has not yet been satisfactorily demonstrated that there have not also been many cases where this plan of procedure was materially departed from, the discharge making a path for itself through the cable and the insulation, or perhaps dividing itself between both routes. In order to obtain more clearly defined ideas of the action of a discharge under these conditions, the apparatus shown in fig. 2 was used, in which it will be seen that the fundamental principles and connections of fig. 1 are reproduced for experimental work, the cloud being represented by the inner coating of the Leyden jar, J, and the earth by the outer one, the charge being produced by a Holtz machine, of which M and N are the conductors. The long length of the cable in fig. 1 is replaced by a short one, K. As before, L represents the line wire, and in this case is connected directly to the conductor, O, in the cable. The lightning arrester is replaced by an equivalent, C, composed of two points separated at an appropriate distance. The wire W is, as before, the ground wire connecting C in the former case to the earth, and in the latter to its equivalent, the outside of the jar; the lead covering of K is also connected by means of a short wire to the same outer surface. While in fig. 1 the point on the line, L, which is struck by lightning, is subject more or less to accidental conditions, it is in the case of fig. 2 selected and adjusted by the ball, X, as is also the value of the energy of action, by the areas of the surfaces on the jar, J, and the length of the striking distance, A.

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* A full and illustrated description of this will be found in the REVIEW for June 24th, 1887.

† Paper read before the American Institute of Electrical Engineers, at the College of the City of New York, January 8th, 1889.

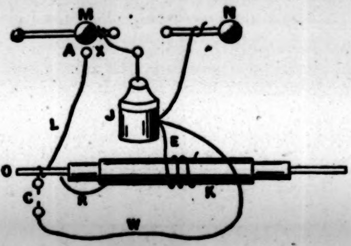

Fig. 2.

With the apparatus arranged as just described and illustrated, it was quickly determined that a discharge could with great ease be caused to pass through the insulation of the cable, even when the space, C, was but a fraction of the distance through the insulation, and the length of W a few inches of stout copper wire. The current of discharge seemed to divide itself, a portion passing by W producing a spark at C, and another portion passing through the cable. A few more experiments also demonstrated that the wire, W, had apparently as much influence on the results as the space C, and consequently it become necessary to analyse the combinations more completely to determine the relative values of C and W. With this object in view, the cable, K, was thrown out of the combination, and the connections simplified to those shown in fig. 3. On close examination they will be found to be in every way similar to those in fig. 2, with the exception of the replacing of the insulation of the cable, K, with a clear air-space, B, and instead of connecting L to the conductor, O, it is here connected to a post, P. The spaces C and B were both adjustable to a fairly accurate degree, B being easily readable to thousandths of an inch.

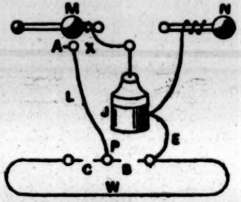

Fig. 3.

The system of experimentation was to take a certain length of wire, W, adjust A and C to known values, and then adjust B so that one spark would occur there for about every ten at A, and after having noted the length of the spark, B, a few inches would be cut off from W and B, readjusted, and again noted, this being repeated until W was wholly consumed. The value of B to these various lengths of W, and a known length of C having been obtained, a wire similar to the original, W, was substituted for the former, and C having been removed from the circuit, as shown in fig. 4, a similar set of tests were made, and the difference between the results, with and without C, indicated the true values of C and W in the combination, while the results with W alone show the value of each additional inch.

In plate A* the results of these measurements have been plotted into curves. The length of W in inches is plotted horizontally, while B in thousandths of an inch is laid out vertically. The capacity of the jar, J, was ·0025 M.F., and A was retained uniformly at ·286 of an inch. The dull line curve is that of W without C in the circuit, while the dotted one is that obtained with it in. The length of C was ·02 of an inch. W for both tests was composed of a copper wire having a diameter of ·052 of an inch.

A brief study of these curves teaches that when W is but a few inches in length, C plays a very important part in determining the length of B, and also that its influence rapidly vanishes as W is lengthened, and actually produces an opposite effect after a certain length of W has been arrived at. Thus, with W 20 inches long, C has a value equal to 59 per cent. of the total circuit. At 110 inches it appears to have no value, while at 180 inches the value of the compound circuit is about 7 per cent. less than W alone. These points are, however, of even less importance than the lesson to be learned from the study of the curve of the results obtained with W alone. Here is a case where a relatively small amount of energy contained on the surfaces of the jar J will, when discharged into the circuit composed of the air space A and the wires, L, W and E, cause the passage of energy in the form of a spark at the point, B, of a length of over one-third of an inch, and this when the wire W is but 20 feet in length, or that of an ordinary ground wire down a telegraph pole.

This does not look very encouraging for lightning arresters with long ground connections, and rather puts to ridicule the fine adjustment of the points of these devices. The subject will, however, stand more than a little study and investigation before forming judgment, and perhaps the arrester is all right after all, in so far as the close adjustment is concerned, even if the long ground connection does have to go.

Those who are familiar with the recent investigations of Prof. Lodge, investigations so exceedingly interesting, and now so celebrated, that few there are who have not made themselves familiar with them, will at once recognise in fig. 4 connections very similar to those used in the experiment of the "Alternative Path," by Prof. Lodge. The results obtained by him and in the present experiments are in the main the same, and those differences that do exist are probably to be attributed to the following facts:—Prof. Lodge's work was done with instruments of great precision, the sparks were always produced between balls or rounded surfaces, and the object was to determine laws and formulate the mathematics of those laws; while, on the other hand, the experiment now being presented were made in some cases under the most difficult conditions, with apparatus limited to a most exceptional degree both in quality and quantity, a certain portion of the sparks were produced between points, and the object in view was to dissect, analyse, and subjugate the phenomena under examination to and for the benefit of practical work, the every day affairs of the electrical profession.

It is, however, exceedingly difficult to avoid a little speculation now and then, as the subject unfolds itself, and it is hoped the experimenter may be pardoned for any references that may be made to the theories that have been the immediate cause of some of his researches. It is even hoped that the work performed may atone for the views about to be advanced, notwithstanding the fact that they are quite contrary to those deduced by so high an authority as Prof. Lodge.

After a considerable portion of this work had been done and the conclusions more or less formulated, I was much pleased and greatly strengthened in the opinions then being formed to learn through a letter from Prof. Hughes to Prof. Lodge, published in the London *Electrician*, issue of September 28th, 1888, that Prof. Hughes had, at least formerly, held the same view of the "alternative path" that I had formed, and which will now be presented in connection with what is thought to be experimental demonstration of their truthfulness.

Referring to fig. 4 it will be seen, as has already been stated, the conditions and arrangements of W and B are such as to produce and actually constitute the "alternative path" as shown by Prof. Lodge. The simple assertion that they are alternative paths does not, however, make them such, and, while they may under certain conditions and adjustments become so, it is possible to conceive of their being otherwise. Is it not within the bounds of reason to assume that the energy that has been discharged from J traverses the wire, W, and in so doing so produces a condition that may be termed *electrification*, and on the disappearance of the controlling influence of this energy, would not the wire, W, return with an almost infinite rapidity to its original non-electrified condition, and, in doing so, produce as the result of this enormous rapidity of motion an electromotive force at its terminals of a greater value than that of the original energy. In other words, will there not be a restoration of the energy expended in distorting the lines of energy within the wire, and this restoration being performed in a shorter interval of time than that occupied in its production, a higher electromotive force would be obtained, even though the value of the returned would be less than that of the original, to the extent equal to the losses due to the internal friction of the mass.

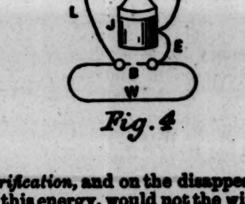

Fig. 4

This being the case, this current of discharge from the wire, and which was first discovered by Henry, and investigated by Faraday, and called by him the *extra current*, would, owing to its greater electromotive force, jump the space, B, and thus close its circuit, even when the distance was such as to prohibit the passage of the original current as discharged from the jar, J.

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* For plate A, see next issue of the REVIEW.

It seems as though this might be the case, and, if it is, then the discharge that was obtained through the insulation of the cable in fig. 2 need not have been a part of the original current from the jar, J, but the current discharged from the wire, W. If it was, a shortening of W would tend towards overcoming the difficulty. To test the case, a short wire, R, was attached to the lead, and bent over the insulation so as to present a point to the conductor, O, the distance between the point and the conductor being about the same as the thickness of the insulation; W was now removed, as was also C. It will be seen that E, the lead of the cable, K, the short wire, R, and the space separating its end from the conductor, O, form an equivalent to W and C. With this arrangement it was not possible to cause a discharge to pass through the insulation.

(*To be continued.*)

NEW PATENTS—1889.

706. "Electric accumulators." M. R. Ward. Dated January 14.

731. "Improvements in conduits for cable and electric railways." W. J. Brewer. Dated January 15.

746. "Improvements in and relating to electric secondary batteries or accumulators." O. Lugo. Dated January 15. (*Complete.*)

757. "Improvements in and relating to a system of suspended bare wires, travelling connections between the said wires and the motor and switches, &c., in and for electric railways." C. J. V. Depoele. Dated January 15. (*Complete.*) [Date applied for under Section 103 of the Patents, &c., Act, 1883, August 9, 1888, being date of application in the United States.]

759. "Improvements in switches for electric railways." C. H. Wells. Dated January 15. (*Complete.*)

765. "Improvements in type printing telegraph apparatus." C. D. Abel. (Communicated by Messrs. Siemens and Halske, Germany.) Dated January 15.

811. "Improvements in the mode of application of magnetism and electricity for medical purposes." J. Garton. Dated January 16.

813. "Separation of aluminium and its alloys from its fluorides by electric or by chemical metallurgic process." W. Diehl. Dated January 16.

859. "Improvements in telephonic apparatus." H. F. Jackson and D. Sinclair. Dated January 17.

877. "A magnetic and sight compass." W. Verner. Dated January 17.

895. "An improvement in or connected with electrical connections for burglar alarms." J. C. Fuller and G. Fuller. Dated January 17.

898. "Combined fire alarm and telephone telegraph." G. C. Hale, A. Barrett and J. Zentner. Dated January 17. (*Complete.*) [Date applied for under Section 103 of the Patents, &c., Act, 1883, June 27, 1888, being date of application in the United States.]

915. "Improvements in electric switches." S. Z. de Ferranti. Dated January 17.

983. "Improved electric time alarm and indicator." C. Adams-Randall. Dated January 19.

997. "Improvements in secondary or storage batteries." T. Cuttriss. Dated January 19.

1006. "Improvements in electrical pole changers." P. Coote. Dated January 19.

1018. "An improved method and apparatus for facilitating the working of telegraph instruments." G. E. Adler. Dated January 19.

1031. "Improvements in dynamo-electric machines." J. W. King. Dated January 19.

1038. "Improvements in and relating to electric lamps for signalling purposes." J. P. Rees. Dated January 19.

1047. "Improvements in propelling vehicles by means of electric motors." M. R. Ward. Dated January 19.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1887.

17415. "Improvements in electrical measuring and recording apparatus." J. G. Lorrain. Dated December 17. 8d. Consists of a U-shaped tube with two bulbs, one at each extremity, and filled partly with a suitable liquid and partly with air or gas. This device is pivoted so as to be capable of a vibratory or rocking motion. Into the bulbs conducting wires pass in an air-tight manner. A current of electricity is caused to pass alternately through the conductors in the two bulbs. The effect of this is to generate heat in the conductor, which, expanding the air in the bulb in which it is situated, drives some of the liquid into the other bulb. This latter, becoming heavier in consequence, sinks, and in doing so causes the electric current to be switched on to the conductor in the bulb, which is now at the lower position. The air is expanded in this bulb, and the liquid forced back into the first-mentioned bulb, which, again becoming heavier, sinks, and so on. The device is thus caused to rock as long as the electric current passes. The greater the current the greater the heat developed, and consequently the more rapid are the oscillations and the greater the number of oscillations which take place within a given time. These oscillations or vibrations are recorded by any suitable known form of mechanical transmitting device, such, for example, as a ratchet and pawl arrangement used in connection with mechanical counters. There is 1 claim.

17726. "Improvements in or connected with electro-motors." J. G. Statter. Dated December 24. 6d. Claim:—The combination of an electromotor having shaping-curve pole pieces and a centrifugal governor regulator, substantially as and for the purposes set forth.

CORRESPONDENCE.

Alkaline Accumulators.

I have not been able, through lack of time, to study the communication in your last week's issue on the above subject; but I do not see M. Lalande's name mentioned as connected with the early idea of using copper to take up the oxygen in charging in an alkaline solution. This must surely be an oversight, because M. Lalande's primary battery (zinc, caustic, potash, and oxide of copper next the negative) is well known both in France and in this country. I had a lot to do with the Lalande battery at its inception in this country, amongst other things superintending the lighting of the Queen's table at Perth in November, 1884, by its means, and I studied it completely. As an accumulator or secondary battery I have used it often. For a miner's lamp I constructed a very light secondary battery, and I have it still by me. I showed it to Prof. Crookes before your recent announcement on the subject. I will give you the details later, but I may say this, that Lalande should be given the credit of this alkaline accumulator, because he showed how it would do. Any improvements that have been made, which I must admit are great ones, on his original plan of using his battery as a secondary, are mainly mechanical. The mistake he made was to deposit the zinc on the mercury. However, this I improved, and obtained excellent results, by depositing the zinc upon gauze of copper or iron and agglomerating oxide of copper in iron gauze, and reducing it to metallic by immersing and short-circuiting with zinc in an alkaline solution, as in the primary battery. I found the gauze very good as the cathode, because it supports the zinc better if it becomes pulverulent or spongy. Weight for weight, I have made Lalande's primary battery 30 per cent. more powerful than any lead-acid accumulator. As an accumulator I have every reason to believe it will be a success, but Lalande's name should be mentioned in its history. We put petroleum on the top in the primary to prevent the potash carbonating. The alkaline secondary battery has made great strides on the Continent.

James C. Richardson.

January 23*rd*, 1889.

Gas Engine Central Station.

Electric lighting makes very slow progress in Britain; we often enough hear this, and it is a truism. We have now central stations in the principal towns in England, also in Glasgow, but the difficulties thrown in the way of establishing a central supply station in a town in the North, makes one wonder that even so much progress has been made. In smaller towns than the above-referred to, it is advisable, if possible, to prevent the gas and electrical interests clashing; however, the gas companies do not attempt to meet you half-way. In a certain place, not unknown to those who seek the country for health or pleasure, it was proposed to erect a small central station as a pioneer of more extensive developments to follow later on. The gas company, however, on being asked to treat with regard to the use of their product in gas engines as prime movers in an electrical plant, gave grudgingly a very minute reduction in price and so saddled it with conditions as to laying mains to the works, and so on, that it practically throws such a proposal out.

It appears to be a prevalent opinion amongst gas engineers that the use of an engine on any gas main will cause all the lights on that pipe to flicker and pulsate even with the modern antifluctuators now in use. Can we wonder that electricians do not attempt to harmonise with the gas interests and also that electric lighting here is so far behind that of our cousins in the States?

C. H. Yeaman.

Glasgow, *January 25th*, 1889.

Electrical Transformers.

I have just noticed in a back number of *Engineering* (March 23rd, 1888), a letter, copy of which I enclose, bearing on central stations worked by underground mains. Placed alongside the repeated and positive assertions of the House-to-House Company, it appears peculiarly interesting. Some of your readers may know of other instances in practical use.

Onlooker.

ELECTRICAL TRANSFORMERS.

To the Editor of "Engineering."

Sir,—I have read with pleasure Mr. Geipel's paper, reprinted in your issue of March 9th (page 238), and beg to be allowed to correct several erroneous assertions in that paper. It states that, with the single exception of Eastbourne, there are no electric illumination plants on a large scale worked with the current from transformers and with underground conductors. Now, as concerns this country (Italy), I am happy to state that during more than two years we have three very considerable central transformer installations supplied with the well-known Zipernowski-Deri-Blathy system, which are entirely worked by underground conductors. The largest of these working installations is that done by the Anglo-Roman Gas Company, which lights already daily upwards of 5,000 lamps, and is continually extending. The other two plants, although not so large as that of Rome, still are of very considerable extent; they are in the hands of the Italian Edison Company, Milan, and Messrs. Bellairs Brothers, Turin.

All the underground conductors for these installations have been manufactured by the house of Siemens and Halske, of Berlin, who have taken special precautions for insuring an irreproachable service, and have succeeded in making cables without perceptible waste of current by induction. These conductors are composed of two highly-insulated concentrical conductors, protected against external and mechanical influences by a lead sheath and double spiral band of iron. Upwards of 40,000 metres of such conductors have been laid in Italy alone, and nobody has ever complained of them.

Should you find it desirable, I can give you further details.

You would oblige by publishing these remarks.

I am, Sir, yours truly,

EMILIO MAGATTI.

Engineer to MM. Fratelli Moleschall.

Rome, *March 14th*, 1888.

The Insulation Resistance of Electric Lighting Installations.

The subjoined letter, of a semi-confidential character, has been addressed to us. The writer possibly did not intend it for publication, but as we preserve his incognito, and since there are some grounds for the complaints he very forcibly formulates, we do not hesitate to reproduce it. While admitting the justice of many of his strictures, we beg to assure those gentlemen who may feel themselves unjustifiably attacked that we do not support the writer's method of expressing his grievance, nor do we think him fair in the onslaught he makes upon the Institution. It surely must be one of the objects of the association to encourage its younger members in writing papers and in taking part in discussion.

The communication reads as follows:—

It is with mingled feelings of disappointment and indignation that I address you, and I trust that in the columns of your widely-read journal some one better qualified than myself may take the matter in hand. The sentiments, above alluded to, which have compelled this letter, were evoked by the paper emanating from Prof. Jamieson, and read before the Institution of Electrical Engineers on the evening of the 24th January. The feelings referred to were considerably aggravated by the drivel, politely termed discussion, which followed the reading of the paper.

Now I am not an electric lighting engineer, and I attended the meeting in a spirit of due humility, intent upon receiving instruction. I came as a learner, I left as a scoffer, rejoicing that I was not as one of these.

I obtained satisfaction, such as might be procured by a comparatively ignorant person, from reading Sir Wm. Thomson's able inaugural address; that gentleman might well exclaim, after the exhibition on the 24th inst., "après moi le déluge." The re-baptism of the society has not attracted the auspices of a benignant star, but let us pray "absit omen."

I would ask, as a searcher after truth, what addition to our knowledge on the subject of either the insulation of conductors, or of the materials most fitting to be used to obtain the desired insulation, has resulted from Prof. Jamieson's paper? We were given excerpts from the Phœnix Fire Office Rules, we were favoured with extracts from Munro and Jamieson's Pocket Book, and as an advertisement for the latter, the paper was no doubt a success. We were also informed of certain experiments conducted by a M. Picon on cotton-covered wires. If, as Prof. Jamieson indicated, the constant obtained in these experiments is too low, why drag such a miserably inefficient insulator as cotton into the argument at all, unless, indeed, to brand it as a fraud? One might as well take as a standard of what a good apple ought to be, the quality of a rotten, worm-eaten specimen, picked up from the ground.

So much for the paper; let us look at the direction taken by the so-called discussion.

One gentleman advocated varnished wood supports as against porcelain, glass and ebonite, owing to the condensation on the surfaces of the latter materials being greater than in the case of the former. He concluded his remarks, however, by mentioning the fact that dry days were usually selected for testing.

Another of the audience spoke of the employment of a small portable dynamo for producing the current required in testing an installation. I should have imagined, Messrs. Editors, that a portable battery would have served the purpose, and have been more easy to handle than a species of barrel organ or a coffee mill.

One young gentleman mentioned the case of an installation in which, in damp weather, a very serious leakge was observed on taking the preliminary tests. The full working current was then applied and the leakage disappeared. This experiment was repeated, I do not remember how often, but the results were always the same under the same conditions of weather. Now, is it a practice in electric lighting to run the risk of burning down your house in order to improve the insulation? Such a method savours somewhat of the Chinaman's plan of roasting a pig.

A budding Faraday enunciated his opinion that vulcanised rubber was, owing to its want of elasticity, far inferior for the purposes of insulating conductors to pure rubber. It may be of future use to this genius to remember that the mastication of rubber reduces its elasticity, but the subsequent vulcanising completely restores it.

One gentleman, not content with addressing the meeting from the benches, found it necessary to vent his opinions alongside the platform, where he executed diverse gymnastic feats with chairs, in, so far as I could make out, attempting the Japanese butterfly trick with the proof sheets of Professor Jamieson's paper. What he actually said was of minor importance.

One youth complained that those Machiavellian villains, jointers, I think he called them, were in the habit of slapping on Chatterton's compound in cart loads when joint making in rubber-covered conductors.

The only sensible speech came from a gentleman who, evidently well acquainted with the subject under discussion, happily stigmatised the use of Chatterton's compound in rubber jointing as a "bastard" method, since the mixture was largely composed of gutta-percha. He also suggested that the gentleman who condemned vulcanised rubber was probably thinking of the external tape, which was not rubber, and which might crack when subject to bending. His remarks that it was not so much a very high insulation that was required but a moderately good but constant one, and that tests taken in dry weather and on a newly erected installation were most delusive, certainly hit the right nail on the head, and were about the only mention of insulation made in the discussion.

The worthy chairman rather put his foot in it, to use a homely but expressive phrase, when he spoke of the difficulty electric light engineers met with in obtaining good material from contractors. The real trouble it seems to me, is that these so-called engineers actually do not know what they want. If, say, a 100-light dynamo is asked for and 300 lights thrown into the circuit, or if leads are specified whose material can only offer a resistance to a stress of say 100 volts, and 500 volts are used on them, can the contractor be blamed if something goes wrong?

The foregoing, Messrs. Editors, is a concise report of the meeting. For this we were dragged on a winter's night from our pipes and firesides. We had not even the consolation of "all this sack for one poor pennyworth of bread." We were beguiled into expecting some information on insulation, and were treated to some rules and formulæ which we could have read in the text books comfortably at home, and to some vague talk about wood, plaster of Paris, jointer's hands, &c.

I remain, yours regretfully,

Despondent.

P.S.—I can now quite understand the reason of the professor's absence from the meeting. If, as was stated, he hoped to elicit some information of possible value, he might have commenced the operation by giving the meeting something substantial to discuss. The absence of most of those men who are shining lights in the electrical world was noticeable.

Prize Competitions.

Can you or any of your readers give information about the Prize Competition for the design of a 10 H.P. electric motor which was instituted by your contemporary *Industries* at the end of 1886? Have the judges come to any definite decision? and why are the designs of unsuccessful competitors refused to be returned at this date after more than two years' detention?

A Competitor.

London, *January* 28*th*, 1889.

[We are sorry we cannot give our correspondent the information he desires. Probably there are many others in the same fix.—EDS. ELEC. REV.]

Bath Electric Lighting.

I should not have troubled to reply to Mr. Winkworth's letter had he confined himself to facts; but he tries to mislead your readers by what I can only describe as a perversion of the truth. He asserts that the Bath Corporation have "somewhat reluctantly" concluded a contract with me, &c. The exact contrary is the case. At my suggestion the Corporation decided to entertain lighting all the principal thoroughfares with arc lamps, and grant facilities for the supply of private lighting. This question has been under their consideration for more than 12 months. Advertisements for tenders appeared for two successive weeks in each of the electrical journals; each contractor was required to tender overhead and underground mains. Ten tenders w received, of which the one sent in by myself (on beh of a local supply company) being the lowest, for b overhead and underground mains, was accepted. A those who had taken the trouble to make themselv acquainted with the peculiar difficulties in the way running underground in this city, recommended ov head wires, and the majority of the Corporation bei of the same opinion, that method was adopted. At t meeting, when the final vote was taken, of a coun numbering 54 members, only one gentleman vot against the contract being signed.

Considering that gas for the public lamps is charg only 1s. 11d. per thousand in Bath, the well-wishers electric lighting throughout the country were surpris at the almost unanimous vote of the council. In common with others, the House-to-House Company had th opportunity of tendering; but it does not appear t have answered their purpose to enter the field of fair and open competition.

The following report of what took place when the application of the House-to-House Company was read, shows the feeling of the members of the Bath council:

"Mr. Cox said that was an application for another company to go in and do the work which another company was engaged to do, and before they knew how i was to be done. They were in a transition state a present, and no interference should be allowed. The Chairman: How can we, after arranging with one company, entertain proposals from another? Mr. Sturges: We would not be allowed. The Chairman: Well, I don't think so. Mr. Mitchell then moved, and Mr. Sturges seconded, that the matter be referred to the Electric Light Committee. This was unanimously agreed to."

The opponents of electric lighting in Bath are delighted at the "dog-in-the-manger" policy of the House-to-House Company, but the friends of electricit naturally regret it. The insinuation of the secretar of the House-to-House Company, to the effect that the possess the most perfect installation yet constructe and are the only people capable of undertaking cent station work, may be correct, or it may be their opini only. In any case, I prefer to employ firms of standin and repute, who have always given me unqualified satisfaction, but whose names I purposely withhold, as I d not wish to make your correspondence columns a mean of advertising any particular firm or company. The secretary of the House-to-House, in true imitation o the Maxim-Weston Company in its worst days, refe to my calling in terms neither true nor complimentary. I am usually described as a boot and shoe manufacture and leather merchant; but this gentleman very politely designates me a "boot and shoe maker."

During the past four years my association with the electric lighting industry has been of a most agreeable character, and all professional electrical engineers with whom I have come in contact have been honourable business men, and gentlemen; but the promoters of the House-to-House Company appear to differ in some respects from those hitherto met with.

H. G. Massingham.

Red Wire v. Black.

In specifications for wiring, it is frequently stipulated that red wire be used for the leads, and black for the return.

Although there may be some slight advantage in this arrangement, we feel sure that no one would wish to insist upon its adoption at a sacrifice of efficiency.

We have invariably found, especially in damp situations, that the red wire shows a marked inferiority both in insulation and durability, and we shall be glad to hear whether this is confirmed by the experience of other electric light contractors.

We may add that this applies to wires of all manufacturers that we have employed.

Drake and Gorham.